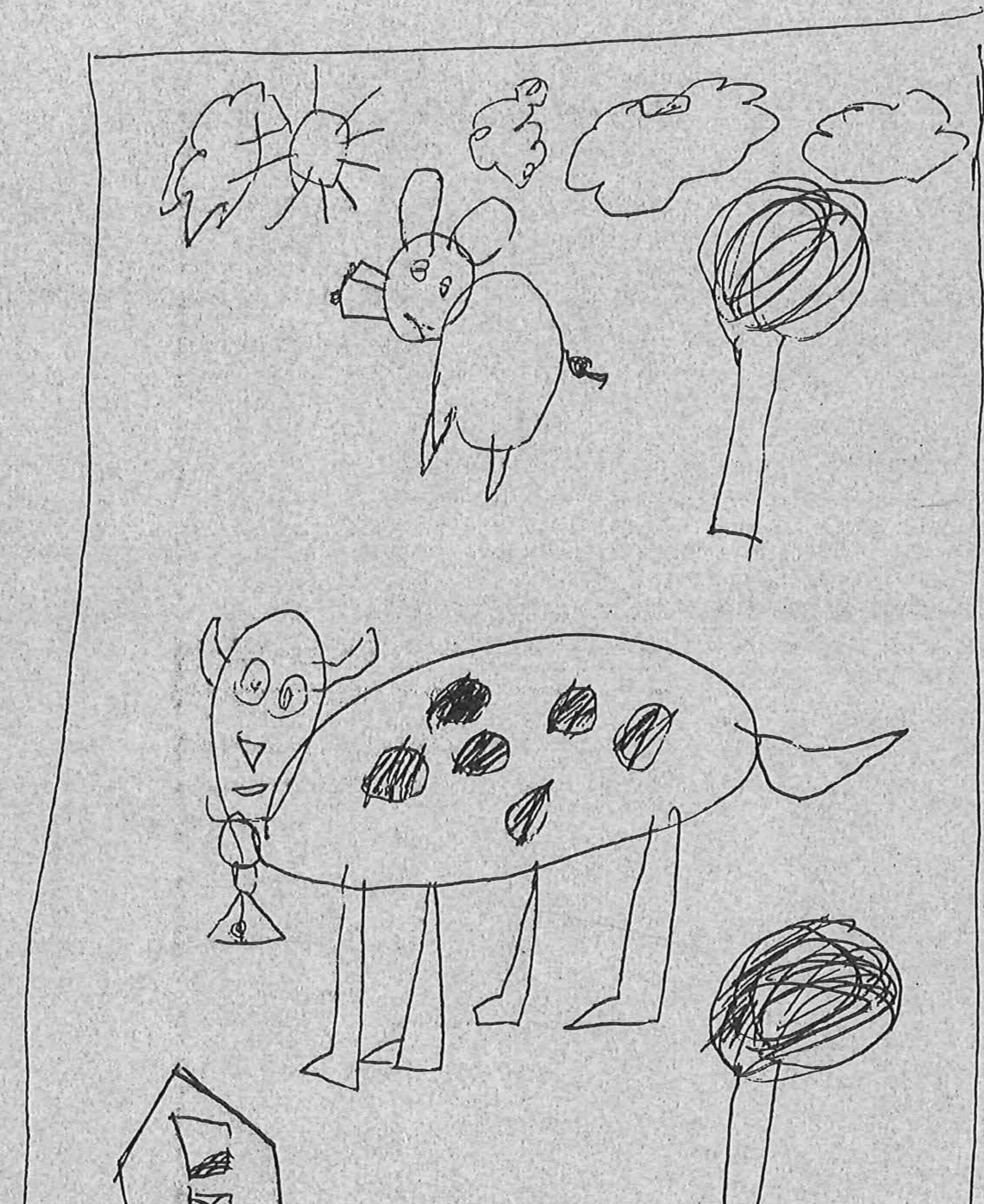
Greenbook '93



Drawing by Joseph Boyd-Brent, age 4-1/2

Minnesota Department of Agriculture
Energy and Sustainable Agriculture Program

Greenbook '93

Energy and Sustainable Agriculture Program
Minnesota Department of Agriculture
90 West Plato Boulevard
Saint Paul, Minnesota 55107
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June 1993

Edited by
Charlene Chan-Muehlbauer

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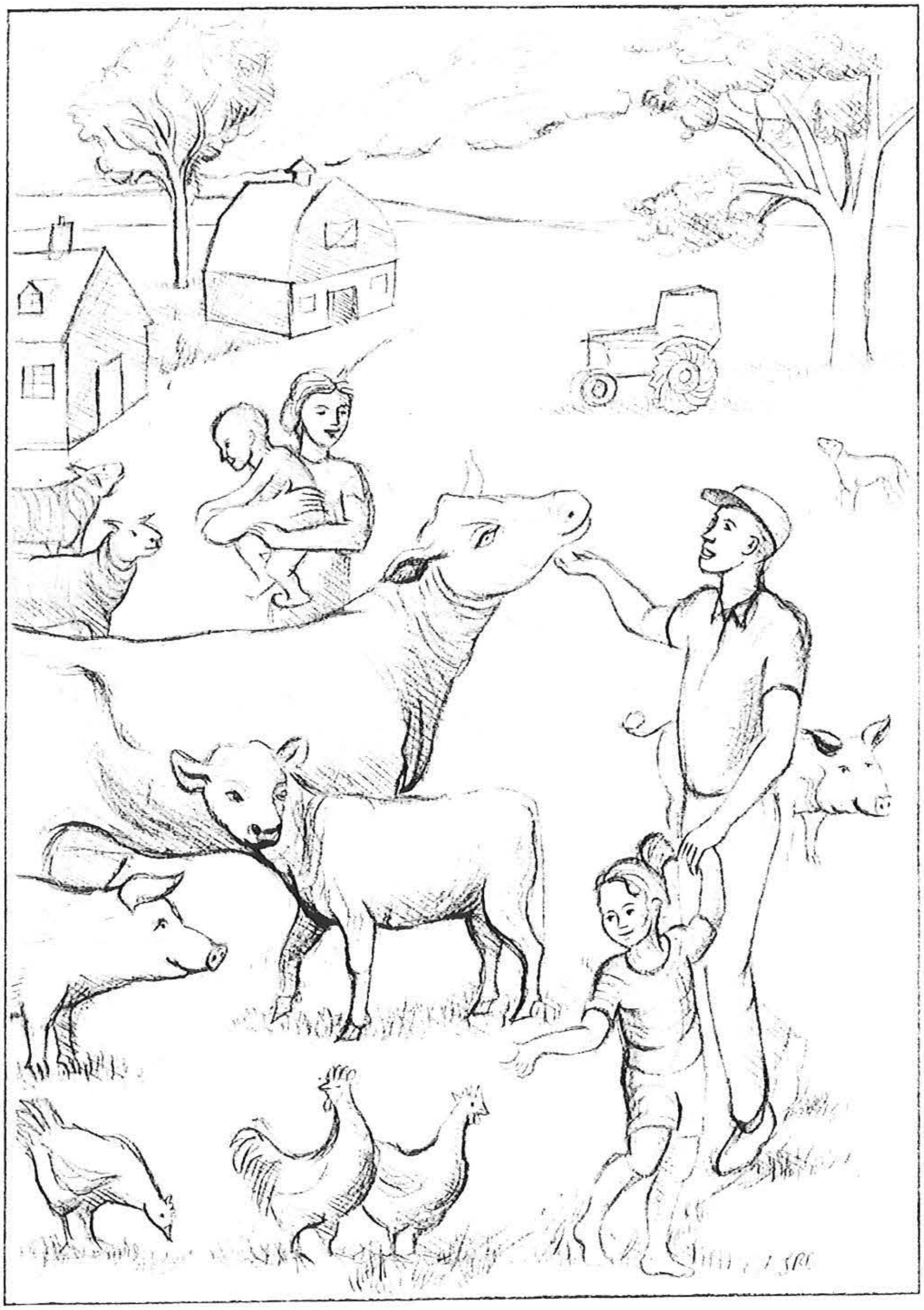
greenbook
June 1993

Perspectives

.....We asked several people to share their perspectives on sustainable agriculture with us. These people have spent many years farming, studying agriculture, or marketing agricultural products and have gained valuable experiences and insights. We hope you enjoy their essays, which can be found throughout the Greenbook '93.



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A FARMER'S VIEW OF SUSTAINABLE AGRICULTURE

Larry Olson
Route 1, Box 136
Granite Falls, MN 56241

"Twenty-five Simple Ways to Loose Those 25 Extra Pounds," was the title on the cover of a magazine in the waiting room of the dentist's office in which I sat waiting for my son recently. Since my vanity keeps me questioning my weight, I took a closer look. Much to my depression I discovered that the ideas were simple enough, but the work and discipline involved definitely challenged me. It's not easy these days to transcend the prevailing desires to have it "right" and to have it "now." We farmers are not immune to that desire, in fact it may be one of the factors that has contributed to the financial stress and demise of so many farmers.

It is vital for farm families to have a vision for their farm operation. It is absolutely essential for the family to understand the quality of life every one wants, the values that inform that life, and the unified will to achieve that goal. This information is not new and it is simple to state, it is however lots of hard work to achieve. It is my increasing conviction that it is well worth the effort expended. I am also growing in my appreciation consistent with my values. I fully recognize the need to be profitable but have discovered that it can not satisfy a farmer's spirit alone. Work must have meaning in the doing not just in the outcome. Work for work's sake tends (like work for money only) to consume people. Work or effort that moves one towards a community or family goal and informs that goal can be a spirit filling experience.

Most farmers I know believe in being husbands of their land and animals. They know that what they do affect future generations and as the doctor's motto wish "to do no harm." It would be arrogant of me to imply that our farming practices are sustainable and other people's are not. It is my intent in this short essay to share what we are doing and some of the results, then let the reader reach their own conclusions.

The agriculture of our time is very capital intensive and dependent. This has made it very hard for those who try to enter without large amounts of available capital. We are not a family with large amounts of capital. Therefore, we have chosen to make use of all the elements in Agriculture that are cheap or free. We also believe that nature (creation) does work. Our problem is that we know so little about how the ecology really works. The new Science of Chaos offers food for thought: "Simple systems lead to complex behavior, and complex systems lead to simple behavior." It appears that diversity in a system makes it more stable. It is this principle that has led us to a farming system that is growing in diversity.

The road to our present farm operation has had several detours that most often have led to new insights. An example of this was watching an early weed flush which we later controlled with mechanical tillage--effecting our potential yield. One of corn's weak links is that it sets its potential early. If it does not have adequate plant food, light and moisture early, the potential will be limited. A question we have learned to ask is "so what is the weak link of weeds?" We also assumed that legumes fixed nitrogen and could supply what we needed for corn production. It did not, however, when we harvested the alfalfa for feed or sale. We discovered that the dry matter of legumes provides much of the nitrogen benefit. This has led us to the conviction that we need to integrate livestock with our cash crop production, to use hay, and to provide manure.

We presently have a seven year rotation of corn, soybeans, small grain, legume for harvest and profit, legume for rest and soil renewal. Livestock manure and the dry matter of legumes help us maintain our soil fertility while improving organic matter from 2.5 in 1980 to 4.3 in 1991. Although we have no scientific information to support us, we believe our soil aggregate and moisture infiltration have improved also. We manage our residue as if it were future plant food. Our ridge till row crop system enables us to create compost piles between the rows which are stirred during cultivation without disturbing the worms very much. Crop residue and the soil biology are not something we have to import or expend cash for. Proper management of both are vital to our operation. We also feel that the rotation contributes to better yields. Weed control is two double rotary hoeings for grasses and three cultivations with the last being for ridge formation. Rotation also helps with weed control and fertility maintenance.

A very big and important question knowing about a rotation like this one is whether it is profitable with a rest year and small grain included. The following information is based on the last five years of full production on our farm. The net profit per acre has ranged from $112 to $125 with a five year average of $115. This is based on five year average yields of 133 bushels for corn, 45.7 bushels for soybeans, 85 bushels for oats, and 4.7 ton of alfalfa per acre. Everything is included except return to labor. We have used very little herbicide, no insecticide and have benefited greatly from the rotation effect.

A second big question has to do with labor/time demands in such a system. The total human hours to perform and manage this system were 548 hours annually. See Table 1 for details. The spreading of manure is not included, since that process is done by someone hired and is included in the production cost of the crop.

Planning time during the winter is not included because we try to include our extended family in the process as we enjoy a long winter weekend around a motel swimming pool. Making arrangements for manure spreading, getting seed prices etc. are often a distraction from my second job as a pastor and therefore, not included. We have decided to call the field inspection walks recreation and continued education since it is delightful exercise and a challenge to our observation skills. I have not included the livestock time/profit/loss figures since we presently have so few and they are more for recreation and responsibility for our children.

Table 1

ACTIVITY	HOURS/ACRE	TOTAL HOURS
Stock chopping	.33	22.85
Seeding	.23	7.88
Planting	.25	34.28
Rotary Hoe	.16	21.95
Cultivation	.94	128.89
Hand Weeding	1.16	79.52
Alfalfa Harvest		83.98
Mowing	.70	
Raking	.35	
Baling	1.40	
Oats Harvest	.35	11.99
Soybean Harvest	.35	23.99
Corn Harvest	1.00	68.86
Repairs		65.00
Total		548.87

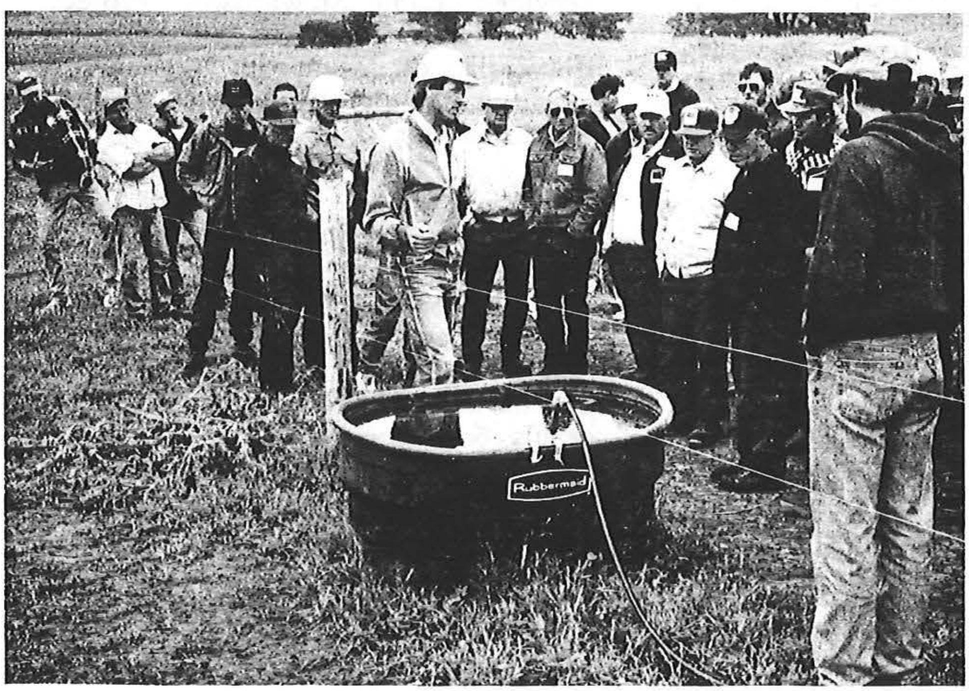
It has been our experience that ideas like the natural system of things are evolutionary in character. Ideas will adjust as observation skills improve and more persons in the operation are included in the decisions and production benefits.

Our system is profitable yet not over demanding of time and labor. It is also exciting because it creates a lot of challenges for the mind and forces us to be in constant relationship with the land and the livestock. Is our system sustainable? I do not know if the environment will sustain our use of it with this system. I am concerned that we need to find a way to keep the soil covered throughout the year. We disturb and expose the soil to the sun and air and loose carbon during that time. It is our feeling that this system is a step in the right direction.

I hope that this short essay has exposed the reader to some ideas worthy of consideration and been informative about the profitability and labor expectations of moving in this direction.

Carolyn, Larry, Cory, Rachel, and Matthew Olson farm the 240 acres of land Carolyn grew up on in Stony Run Township of Yellow Medicine County. They have been exploring what is best for themselves and the land since 1978 when they returned to the farm from the parish ministry in South Dakota. Since 1986 Larry has served a congregation in a neighbor town on a 5 day/week basis. Larry serves as chair person on MDA's Sustainable Agriculture Advisory Task Force and on the Land Stewardship Project.

Sustainable Agriculture Demonstration Grant Program.....



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Grant Program

Purpose

The Grant Program provides a unique opportunity for farmers, non-profit groups, agricultural researchers, extension agents and educators across the state to work together to explore ways of enhancing the sustainability of a wide range of farming practices.

Project Goals

The Department has received over 450 grant applications and has approved 64 for funding since the program began in 1989 Thirteen new demonstration grant projects proposed by farmers, educators and researchers were funded in 1993.

Grants provide a maximum of $25,000 for on-farm demonstrations that last up to three years. The projects should demonstrate farming methods or systems that increase energy efficiency, reduce agricultural chemical usage, and show environmental benefit. The Technical Review Panel, made up of farmers, university agricultural researchers, extension agents and educators, evaluates the applications on a competitive basis and makes recommendations to the Commissioner of Agriculture for his approval.

Category of Sustainable Agriculture Grants Approved 1989-1993

Category	Number of Grants
Intensive Rotational Grazing	23
Cropping Systems	12
Soil Fertility/Tillage Systems	10
Soil Building and Weed Mngment	10
Specialty Crops	10

Summary of Grant Funding (1989-1993)

Year	Number of Grants Funded	Total Funding	Average Grant Size (Range)
1989	17	$280,000	$16,500 (3-25,000)
1990	14	189,000	13,500 (4-25,000)
1991	4	46,000	11,500 (4-23,000)
1992	16	177,000	11,000 (2-25,000)
1993	13	85,000	6,000 (2-11,000)
Total Funded	64	$777,000	

Field Days

The grant project participants hold public field tours every year to share what they have learned and accomplished in their demonstrations. This year approximately forty field days, based on demonstration grants funded over the past three years, were sponsored by ESAP in cooperation with Minnesota and County Extension Services, Land Stewardship Project, Rodale, state Technical Colleges, the University of Minnesota, Sustainable Farming Associations and several agribusinesses.

Grant Summaries

The project summaries that follow are brief descriptions of objectives, methods and findings of individual grant projects funded over the last three years. To find out more details about these projects, contact the principal investigators directly through the listed telephone numbers and addresses.

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SUN+GRASS+SHEEP = $

R & K Shepherds
D. Rathke & C. Karstens
61231 MN Hwy. 7
Hutchinson, MN 55350
612/587-6094

A gross margin of $1000 per acre? It sounds too good to be true. Is it even possible? It's not uncommon with seasonal grass dairying, but sheep? The answer is yes it is possible. It can be done by changing to a grass based operation along with some marketing ingenuity. We made the switch and here's how we did it.

Five years ago we decided that we needed our sheep operation to work for us rather than us working for it. It was evident that our flock size was too small and that our expenses were too great for it to become a lucrative business.

With over 20 years of ovine experience from each side of our partnership, we were far from green in the sheep business. After one of our trips to New Zealand seven years ago, we were introduced to the kiwi style of sheep farming. It was then that we first began to think out of the traditional paradigm which we had previously patterned our own operation. The New Zealand grazing methods, their pasture lambing, and their reasons for culling made sense to us for the simple reason that lower inputs can generate higher profits. We soon came to realize that greatest productivity is not necessarily greatest profitability.

For us to start making some real money with sheep, we needed to approach it as we would any other business. It became obvious that not only were we in the sheep business, but, perhaps more so, we were in the grass business and the sheep were simply the mechanisms we chose to harvest the grass crop we were growing. But since we are in a business, profit and quality is our bottom line.

As we see it, in order to increase our profits two things could be done: 1) lower the inputs or 2) get a higher price for the product produced. Rather than opting for one of these, we resolved to do both. We achieved the goals by use of management intensive grazing practices and by direct marketing our pasture finished lambs.

Lowering Feed Costs

The best way to lower inputs is through lowering feed costs since it accounts for the sheep's number one expense. We figured what better way to reduce those costs than by harnessing nature's free solar energy in the form of grass. We found we could eliminate nearly all machinery costs. We custom hire our hay bailing and soon we will purchase the hay needed for the winter which will prove more economical for our situation. The only machinery we use is an old tractor, a mower, and a borrowed manure spreader--definitely low inputs. But it's really all we need for now. All producers should ask themselves <u>why</u> they are doing what they are doing and they should know their break even price for their operation. This may prevent unwarranted purchases.

Our Grazing System

Today we management intensive graze 100 purebred accelerated lambing Dorset ewes and their lambs on a 12 acre pasture which is divided into 16

3/4 acre paddocks. We begin grazing early April and rotate stock quickly during the earliest part of the Minnesota grazing season. In early spring we are careful not to overgraze and we allow them only to top graze, even if it means moving them several times a day. Once the growth starts to take off, we put the weaned lambs and lactating ewes and their lambs in a paddock ahead of the other groups so that they can select the best feed. By that time, lambs have learned from their older pasture mates what rotational grazing is all about. If needed, we may also provide an old ewe who needs extra attention to act as their trainer. Then our non-lactating ewes graze behind and work as a clean up crew. With our accelerated lambing program our ewes lamb at 7-8 month intervals and our annual lambing percentage is consistently over 200%.

For late fall and winter grazing we use our 16 acre alfalfa field which is in the process of being converted to strictly pasture as to accommodate another 100 ewes. Our grazing season presently is 8.5 months of the year. We plan to double our current flock size to 200 while still maintaining a closed flock. Our 28 acres will easily carry 200 ewes and their lambs. Because of the profit potential we see, our future plans are to purchase more land and increase our flock size even more.

Marketing

The marketing of our sheep products is just as important to us as the way we raise the animals. We feel this aspect of the business can be overlooked. Reality in the sheep business is that we simply can not rely on anyone else to promote lamb so we, as sheep producers, must do it ourselves.

We have chosen to direct market all of our sheep be it as breeding stock, to grocery stores, to individual customers or to metropolitan restaurants. By far, our biggest outlet is the restaurant trade. The potential here is enormous although it does require additional time and public relation skills. Our restaurant sales are such that we are unable to supply all the lambs demanded so we do accept lambs from other producers when needed.

Because of our market, a quality year around supply is a must. This is why Dorsets work so well for our purposes. Our customers can count on a steady source of top quality carcasses. When direct marketing, quality and predictability are the keys. With these two factors in mind, a premium price comes automatic. As we expand our flock numbers, we are confident that our markets will expand as well.

Dollars and Cents

With the sheep business as it is today, the efficient sheep farmer will both survive and thrive in the 90's. Gross margins give a very fair picture of how efficiently the flock is performing. It has been shown that cost reduction will yield more net return than production increases.

We have compiled data showing the comparisons of direct or variable costs which have been determined as part of a 3-year research project with the MDA's Energy and Sustainable Agriculture Program. In order to compare apples to apples, or the two systems equally, both are based on accelerated lambing programs of 7-8 month lambing intervals. The grass based one pastures 8.5 months and the traditional one pastures 4 to 5 months of the year.

Direct (Variable) Cost Comparison of a Grass Based -vs- Traditional System

	Expense-per Head	Grass Based	Traditional
Feed:	Ewe Feed	25.00	43.00
	Lamb Feed[1]	7.00	23.00
Livestock:	Health/Vet Costs	4.00	4.50
	Bedding ($1.25/straw bale)	1.00	5.00
	Ram Costs	2.00	2.00
	Ewe Depreciation (7 years)	15.00	15.00
	Shearing Costs	2.00	2.00
Pasture:	Seed Cost[2]	.08	0
	Fertilizer Costs[3]	.25	0
	Fence Depreciation[4]	1.00	0
	Fuel[5] (for spreading manure)	.02	.05
Operating:	Electricity/Utility/Insurance	1.00	2.00
	Supplies	2.00	3.00
	Equipment/Repairs	2.00	2.50
	Building Costs	1.00	4.00
	Total Out of Pocket Expenses	63.35	106.05
	Break Even Point	28¢	46¢

[1]Lamb Feed costs based on the fact that we feed only corn, top quality alfalfa, sheep mineral, & iodized salt. No protein pellets. Feed costs are averaged from winter lambs ($11.00), spring lambs ($3.00), and fall lambs ($7.00). Thus yielding an average of $7.00.

[2]Seed Costs based on a planting of Birdsfoot Trefoil, white Dutch Clover, Brome, and Timothy with a 20 year depreciation which totals $21.88 per year. $21.88 ÷ 300 head = 7¢/head.

[3]We designate $75/year for fertilizer costs, whether used or not. $75.00 + 300 head = 25¢/head.

[4]Fence depreciation is based on 20 years with a total of $4,000.00 set up costs. $200.00 per year + 300 head = 67¢/head plus 33¢ head for improvements = $1.00.

[5]Fuel expenses are based on a total of $6.00 used for tractor gas. $6.00 + 300 head = 2¢/head.

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Profit Calculations for Grassed Based System

Based on:
- * 200% live lamb crop
- * 115 lbs. market weight
- * Direct market year around price of 85¢ per pound (Delivery fee paid by customer)
- * Wool income, incentive payments, sale of culls and breeding stock are not included in this gross income calculation because the sum of these sales is equivalent to the cost of the ewe lambs retained for replacements.

230 lbs of lamb/ewe x .85/lb = $195.50 Gross Income/Ewe

$195.50 - $63.35 Out of Pocket Expenses = $132.15 Gross Margin/Ewe

$132.14 (Gross Margin/Ewe) x 8 Ewes & Their Lambs (Stocking Rate/Acre) = $1057.20 Gross Margin Per Acre

Then to calculate your net income:
Gross Margin - Fixed Costs (labor, machinery, building ownership land payments) = Net Income

Since we have changed our management approach, greater cash flow is just one of the many gains reaped from grazing. Firstly, labor per animal unit is substantially reduced and that is why it is easier to handle more and more ewes. Although actual hours of hand feeding animals subsides, a higher degree of management skill is practiced.

We have found that the less we interfere with the ewe at lambing time, the better. Mother Nature has given her the necessary instincts to function all by herself. In nature, the problem ones die off. At our farm, we cull most ewes who are unable to raise their lambs unassisted, whether it be due to unsound udders, poor mothering traits, or repeat dystocia. Ewes are also culled if they show no regard for fences, electric or otherwise, as they may influence their pasture mates with their poor manners. Our culls are privately sold as valued-added meat products.

Since our switch to grass, health problems are becoming a thing of the past as have middle of the night lambing checks. The lambing times are no longer a dreaded task of sleepless nights, but instead a pleasant experience. There certainly is no lambing time "burn-out" for us even with our acceleration program. We believe the reduced stress level of the pasture situation is one factor in eliminating ill-health. Another major factor which prevents problems is that the sun and fresh air naturally help kill harmful bacteria which are often the root of the ailment.

When we do lamb off forage in the winter, we do very little jugging anymore. Only triplets and inexperienced first time lambers with twins are jugged.

Over the years, we have developed a self sufficient, easy keeping, productive flock with a high yielding carcass which we believe offers elite genetics to both commercial and purebred breeders alike. Detailed record keeping has been the basis for selection. Among other things, our weaning weights are a true measure of milking ability since our lamb creep pen offers only top quality hay and whole corn.

The pasture lambs have ADG of .61 lbs. and through perfecting our grazing skills we are certain to hit .751 lbs. soon.

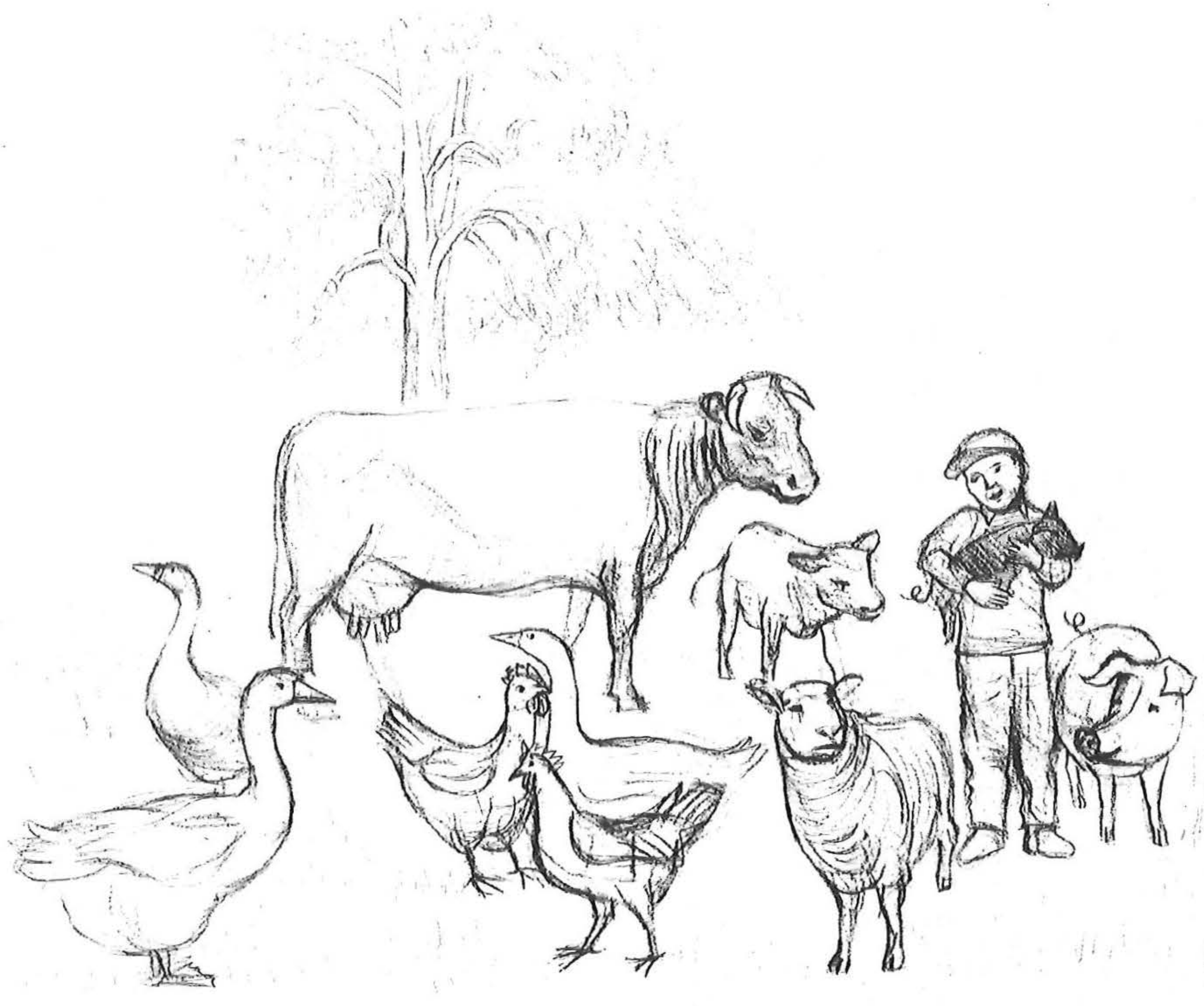
Yet another benefit for the grazing is the improved wool quality. The fleeces are cleaner, brighter, and higher yielding and thus are worth more. We are starting to have requests for our quality handspinning fleeces.

We are well aware that most graziers choose a one time spring lambing as opposed to the accelerated system. However, for now, since we have the market demand and we are in the purebred Dorset business, we feel obligated to insure the integrity of the breed through breeding for short lambing intervals. Perhaps as our family grows older, we may opt for the once a year lambing that coincides with the lush spring growth.

These methods of grazing, without a doubt, have been the best thing we have done for our sheep operation. It has brought a renewed enthusiasm back to sheep farming. We marvel at the joy we find as we work with the plants, animals, and nature--it truly has become a labor of love.

Doug Rathke and Connie Karstens and their 31/2 year old daughter, Kata, operate R & K SHEPHERDS near Hutchinson, Minnesota. Doug is a professional sheep shearer and a National Shearing Program instructor. Connie works part-time as a Technical College instructor and for a large animal vet clinic. They also do grazing consultations and speaking.

Livestock.....



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Project Title:	**Economics of Rotational Grazing Verses Row Crops**	*Time Span:*	March 92 to October 93
Principal Investigator: *Address*	Harold Tilstra RR 2, Box 162A Luverne, MN 56156	*Tel:* *County:*	507-283-4019 Rock
		Enter-prise	Beef, corn, soybeans

Project Description

Twenty one acres of prime corn/soybean land were converted to intensive rotational grazing of a beef cow/calf herd. These acres were compared to a field of soybeans the first year and will be compared to a field of corn the second to see if grazing can compete with row cropping on an economic basis. By comparing the pounds of gain on the calves, less the expenses, to the return per acre of row crops will show if intensive rotational grazing is a viable economic alternative to row cropping..

Project Results

Tilstra used a 19 acre soybean field and a 21 acre intensive rotational grazing pasture for the comparison study.

The soybeans were ridge tilled with a pre-plant burn-down herbicide application, banded post-emergent herbicide application, and 2 cultivations. The soybeans yielded 39 bushels per acre.

The 21 acre pasture was divided into 8 grazing cells in a wagon-wheel design. 32 cow/calf pairs were put on the pasture on May 10 and 32 calves were taken off pasture on October 10. The calves gained 300 pounds on the pasture in the 142 days. Tilstra spent about 1/2 hour a day to move fence and manage pasture and animals.

June was a very dry month and the pasture did not grow. Tilstra supplemented the cows and calves feed with some hay and silage until mid-June. The rest of the summer was very wet and the pastures produced very well and no more supplemental feed was needed.

Gross Margin Analysis of Tilstra IRG Project for 1992

Number of Acres in IRG pasture	21
Number of paddocks within pasture area	8
Type of livestock	beef cow/calf
Number of Head	32 cow/calf pairs
Stocking rate per acre (AU)[1]: (# of head)x(Ave. wt.)+(100 lbs)+acres	2.2 AU/A
Date animals began grazing in 1992	5-10-92
Date animals stopped grazing in 1992	10-10-92
Total number of days out on pasture	142
Estimated labor: time/day	30 minutes
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head)	2.11
Gross Profit ($) from Pasturing Acres	
Beef Sold ($)	9,120.00
(32 calves @300# gain @ $95/cwt)	
Total Gross Profit	9,120.00
Gross Profit/Acre	**434.00**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Hay	50.00
Mineral/Salt	320.00
Forage	432.00
Total Purchased Feed Costs	802.00
Operating Expenses for Pasture	
Labor Costs (seasonal only)	360.00
Total Operating Expenses	360.00
Total Variable Costs	**1162.00**
Variable Costs/Acre	**55.00**
Gross Margin/Acre[2]	**370.00**
(Gross profit/acre - Variable costs/acre)	

[1]AU = Animal Unit which is 1000 lbs. of animal weight.
[2]Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.

Gross Margin of Tilstra Soybean Project for 1992

Number of Acres in Soybean Project	19
Gross Profit/Acre	**195.00**
(39 bu/acre @ $5.00)	
Variable Costs/Acre (Out-of-pocket Expenses)	
Chop stalks	6.90
Spray burndown	3.80
8 0z. Roun-up/2-4-D	3.31
Seed	18.00
Ridge planting	10.40
Pursuit	9.00
Band spray	3.80
Pinnacle	2.00
Cultivate 2 times	9.10
Walk beans	2.50
Combine	18.70
Total Variable Costs	**87.51**
Gross Margin/Acre	**107.49**
(Gross profit/acre - Variable costs/acre)	

In 1992 the the Gross Margin with the calves on pasture was $370 and for the soybeans was $170. The Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc. The Gross Margin earned is calculated only for the months during which the land is used for grazing, or for producing crops.

Management Tips

1. Tilstra would not recommend the wagon-wheel style lay-out of the grazing cells. The cells are quite narrow at the central hub area and there was trouble with mud and breaking of the sod in this area.

2. Be ready to supply additional feed to the stock if weather conditions are such that the pasture does not supply all the feed required.

Location of Project

From Luverne go south on Hwy 75 to County Rd. 59, go west on 59 two miles, then south on township gravel road for 1 1/2 miles, the project is on the west side of the road.

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Project Title:	**Backgrounding Beef Cattle/Rotational Grazing**	*Time Span:*	January 1992 to December 1994
Principal Investigator: Address	Frank Schroeder RR 1, Box 378 Cushing, MN 56443	*Tel:* *County:*	612-749-2398 Morrison
		Enterprise	Beef, pasture

Project Description

Frank Schroeder wants to get away from the high inputs, the high machinery costs and the low returns that come with grain farming. By going to rotational grazing Schroeder wants to see if backgrounding feeder cattle during the growing season between May and October is economically competitive with grain farming. By developing the best pasture paddock system for maximum returns and determining the stocking rates for this pasture system Schroeder will measure the dollar returns on these acres.

Project Results

The 80 acre improved pasture was seeded the spring of 1991 in barley stubble to Arlington red clover. There was also 40 acres of natvie pasture that was used as back up for clover when it was very dry. This was grazed for 9 days. One hundred twenty (120) head steers were put on the pasture May 15, 1992 weighing an average of 609 pounds. One steer died 2 days after delivery, 4 died of bloat, and 2 disappeared for a death loss of 5.8% The calves ate only from the pasture until they were sold on September 14. They gained 2.16 lbs/day for an average of 872 pounds in the 122 days they were on the pasture. Considering the weather conditions and the lack of grass in the stand, the pasture did well and Schroeder was satisfied with th growth rate of the cattle.

Gross Margin Analysis of Schroeder's 1992 IRG Project

Number of Acres in IRG pasture	80
Number of paddocks within pasture area	14
Type of livestock	beef stockers
Number of animals on pasture	120
Stocking rate per acre: (# of head)x(Ave. wt.)÷(1000 lbs)÷acre	1.1 animal units/A
Date animals began grazing in 1992	5-15-92
Date animals stopped grazing in 1992	9-14-92
Total number of days out on pasture	122
Estimated labor: time/day	1 hour
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head)	2.16
Gross Profit ($) from Pasturing Acres	
Beef Sold ($)	17,173.00
	(263 lbs. ave. gain/head)
Total Gross Profit	**17,173.00**
Gross Profit/Acre	**215.00**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Concentrates	481.00
Total Purchased Feed Costs	481.00
Pasture Expenses	
Seed costs	400.00
Total Pasture Costs	400.00
Operating Expenses for Pasture	
Labor costs (seasonal only)	500.00
Livestock Hauling	200.00
Interest	3,000.00
Miscellaneous	300.00
Total Operating Expenses	4,000.00
Total Variable Costs	**4,881.00**
Variable Costs/Acre	**61.00**
Gross Margin/Acre[1]	**154.00**
(Gross profit/acre - Variable costs/acre)	

[1] Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.

Management Tips

1. Paddock size of 5.1 acres was too large for the steers to effectively graze. Schroeder thinks that a paddock size of 2.8 acres for 80 steers would be more appropriate. Set the paddock size so that the cattle can graze the whole paddock in 1 day.

2. Improving the pasture by interseeding clovers is an excellent investment as it allows the pasture to provide feed longer in the summe. The rate of gain of the steers on the improved pastures was substantially higher than on native pasture.

3. The use of a bloat guard is important becuase the clovers in improved pastures can become lush quickly and cause bloat problems in the livestock.

Location of Project

From Randall go north on County 1 for 2 miles, turn left on County 206, turn left on County 205 go 3/4 mile the site is on south side of the road.

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Project Title:	**Intensive Rotational Grazing on Warm Season Grasses**	*Time Span:*	April 92 to December 94
Principal Investigator:	Jim Sherwood	*Tel:*	507-967-2488
Address:	RR 1, Box 25 Magnolia, MN 56158	*County:*	Rock
		Enterprise	Beef, pasture

Project Description

Many people think that row cropping is the way to farm. Large amounts of chemicals and fertilizers are applied to the soil to make mediocre land more productive. Is doing this making the best use of the land and the natural resources?

In this project, Sherwood is asking that question about his farm in southwest Minnesota. It takes an exceptional year to produce 100 bu/acre corn in these fields. Sherwood will replace row crop farming with rotational grazing a cow/calf herd on pasture consisting of native warm season grasses (Big Bluestem and Switchgrass) and letting nature do the most work for the farm and lowering input costs.

Techniques and management are keys in establishing warm season grasses as some seed will germinate in the 1st, 2nd, or even 3rd year after planting. The pasture just keeps getting thicker. By establishing a warm season grass stand the pasture will provide feed to the livestock during the usually hot and drier months of July and August when the cool season grasses do not grow well.

Sherwood will look at getting these warm season grasses established, increasing stocking rates due to having longer growing season for the pasture, and comparing intensive rotational grazing to row crop farming.

Project Results

This first year of the project was spent in establishing the warm season grasses and very little grazing was done on the plots. Big Bluestem and Switchgrass were planted in 1991. In 1992 Sherwood had to do some spot replanting to get the desired stand. By the 1993 summer the grass will have grown enough to get the cattle on pasture to see how the warm season grasses do in July, August, and September.

Foxtail grass became a problem and was controlled by using atrazine only where needed. Although some cattle grazed briefly in 1992, Sherwood felt that the pasture could have supported heavier grazing. After a two inch rain he discovered that the sod was not built up enough to support the cattle. Until the thickness of the grass is built up there must be other permanent pastures available to turn the livestock on during heavy rainy periods.

Management Tips

1. Be sure to have a weed management strategy in place.

2. Growing warm season grasses requires patience because the seedlings take three years to germinate and develop root systems before the plants start to really grow.

3. Do not fertilize since weeds thrive on fertilizer whereas the native warm season grasses do not require it.

Location of Project

From Kanaranzi go east 1 3/4 miles on 15

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Project Title:	**Intensive Rotational Grazing**	*Time Span:*	April 90 to October 92
Principal Investigator: Address	Chad Hasbargen Route 2, Box 101 Wheaton, MN 56296	*Tel:* *County:*	612-563-8066 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 (100 acres are improved and 60 acres are native grass). The field was divided into twenty-two 6 acre paddocks, and an 18 acre control plot.

Hasbargen's goal was to increase production on pastures with a small investment in money, labor and management, and to double the animal unit grazing days on the pastures.

Highlights from 1990

The cow/calf pairs grazed for 18 hours (noon-6 AM) each day and the ewes grazed for 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.

The sheep were taken out of the rotation system 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. Rotating sheep and cattle twice per day required 4 hours of labor. After the sheep were taken out of the rotation system, and the length of grazing time extended to 3 or 4 days per paddock, the amount of labor required for moving fences was only 1-1/2 hour per move, or 1/2 hour per day. The paddock size was increased from 2 to 6 acres for the cows. The change from a daily rotation to a 3-5 day rotation schedule did not seem to make much difference in animal or pasture productivity. The accumulated rainfall for the 1990 season was 16.67".

Results

1. Rotational grazing increased profit by $2468, or $16.20/A compared to conventional grazing.

2. Rotational grazing increased the animal unit days to 148% of conventional stocking rates.

Animal Productivity Under Intensive Rotational Grazing

Year 1990	Cows (1st calf)	Calves	Ewes
Number	41	38	486
Beginning Wt (lbs)	1005	178	139
Condition Score	4.2	N/A	N/A
Ending Wt (lbs)	1097	440	154
Condition Score	5.5	N/A	N/A
Total Wt Gain (lbs)	92	262	15
Total Days on Pasture	177	122	67
Gain per Day	0.52	2.15	0.22

3. Pasture forage quality contained up to 26.1% protein, with a relative feed value of 173.3.

4. Ewes were moved to paddocks to eliminate brush problems.

5. Overall herd health improved under the rotational grazing system compared to dry lot feeding of the previous year.

Highlights from 1991

Very heavy rainfall (20.91" between May 22-June 14) flooded 50% of the pasture for 8 weeks, and disrupted rotational grazing for 6 weeks. This slowed grass growth and killed 20 acres of vegetation.

1. Intensive rotational grazing increased net profit by $1416, or $9.32 per acre, compared to conventional grazing. Increased profit was due to

additional animal unit days under grazing and hay harvest. Flooding problems reduced the economic benefit of the system.

2. Animal unit days were 162% greater under the intensive grazing system compared to the standard stocking rate for conventional grazing in the area. Part of the increase is due to the 51.2 tons of hay that was harvested in round bales from the improved area of the pasture.

Animal Productivity under Intensive Grazing System

Year 1991	Cows (1st calf)	Calves	Ewes
Number	61	37	97
Beginning Wt.(lbs)	1052	142	154
Condition Score	4.0	N/A	N/A
Ending Wt.(lbs)	1124	461	168
Condition Score	5.1	N/A	N/A
Total Wt. Gain (lbs)	72	319	14
Total Days on Pasture	175	160	147
Gain per Day	0.41	1.99	0.09

3. Cattle gains were lower than last year due to excessive forage moisture and high incidence of hoof rot.

Highlights from 1992

1. The average daily gain on the calves is lower each year with the longer they stay on the pasture before they are weaned. The Hasbargens will move back their weaning date to Sept. 20 to maximize calf gains on pasture.

2. There has been a gradual decrease in soil nutrients since this project began so Hasbargen will use fertilizer in 1993.

3. The grass growth got ahead of the cattle during early spring and some of the forage matured before it was grazed. This results in reduced feed quality. To avoid this problem, there must be more animals/acre on the pasture, and they must be rotated more quickly through the paddocks.

4. Cattle need to be pastured earlier in the spring.

Increased Profit from IRG compared to Conventional Continuous Grazing

Added Costs		Added Return	
Fencing	700	Hay	3230
Labor	750	Added AU*	770
Hay harvest	1070		
Total	2520		4000

*AU = animal units

Net Profit Increase = $1480/160 Ac = $9.25/Ac.

Gross Margin Analysis of Hasbargen's 1992 IRG Project

Number of Acres in IRG pasture	160
Number of paddocks within pasture area	23
Type of livestock	beef
Number of animals on pasture	134
Stocking rate (animal unit) per acre:	0.7
Date animals began grazing in 1992	5-17-93
Date animals stopped grazing in 1992	11-3-93
Total number of days out on pasture	170
Estimated labor: time/day	2 hours
Tons of hay baled/chopped off pasture	80.75
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head)	1.91 (calves)
% Calf crop	100
Gross Profit ($) from Pasturing Acres	
Beef Sold ($)	31,185.00
Hay from pasture: 80.75 T @ $40/T	3230.00
Total Gross Profit	**34,415.00**
Gross Profit/Acre	**215.10**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Mineral/Salt	858.00
Protein	315.00
Total Purchased Feed Costs	1173.00
Livestock Costs	
Veterinarian/Medicine	192.00
Breeding costs	1095.00
Total Livestock Costs	1287.00
Pasture Expenses	
Custom harvesting/baling forage	420.00
Hay harvesting	1070.00
Total Pasture Costs	1490.00
Operating Expenses for Pasture	
Electricity	105.00
Supplies	50.00
Fuel costs	159.00
Labor costs (seasonal only)	1000.00
Livestock Hauling	450.00
Total Operating Expenses	1764.00
Total Variable Costs	**5714.00**
Variable Costs/Acre	**35.71**
Gross Margin/Acre*	**179.39**
(Gross profit/acre - Variable costs/acre)	

*Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.

Other Observations

1. The pasture was grazed much more evenly because livestock were forced to eat the less palatable species. Previously the alfalfa plants were over-grazed and did not have an opportunity to recover and thus were depleted.

2. Less foot paths and camping areas in the paddocks kept the pasture forage healthier and more productive.

3. Rotational grazing requires less manure management and machinery use because animals spread their own manure and harvest their own forage.

4. Overall health of ewes was improved compared to dry lot feed system from exercise and less dust.

Project Summary Sheet of Animal Unit (AU) Grazing Days

	Conventional 1980	Year 1 1990	Year 2 1991	Year 3 1992
Cattle	9900	7627	12,406	15,209
Calves	2610	2040	1785	3391
Sheep	1125	4770	2296	0
Hay	0	6400	5120	8075
Total	13,635	20,837	21,607	26,675
% of Conventional	100%	153%	158%	196%

*Hasbargen's goal is to reach 250% of conventional grazing AU days.

**Conventional pasture animal unit days were calculated using these assumptions:

- 2.5 acres/cow-calf pair (95% calf crop)
- 1100 lb cows weaning 500 lb calf (calf weaned October 1).
- 150 day grazing season
- 50 ewes complementary grazing with cow herd.

Hay is converted into animal unit days:
20 lbs hay = 1 Animal Unit Day.

Management Tips

1. Grazing should begin at least 2 weeks earlier in the spring under the rotational system compared to the conventional system in order to keep grasses from flowering. Once grasses flower, they stop growing and the nutritional quality of the forages are much lower.

2. Consider using permanent paddocks made of high tensile wire if large numbers of sheep (350+ head) are run together to save on labor.

4. Construct alleys wide enough (minimum of 24 feet for 350 sheep or more) if alleys are used.

5. Do not be afraid to change the rotation system mid-season to adjust to changing forage growth in individual paddocks.

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.

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Project Title:	**Intensive Controlled Grazing and Pasture Rejuvenation on Fragile Land**	*Time Span:*	November 91 to Summer 94
Principal Investigator: *Address*	Lyle and Nancy Gunderson 12614 90th St. E. Northfield, MN 55057	*Tel:* *County:*	507-645-8248 Rice
		Enterprise	beef cattle

Project Description

This farm consists of steep slopes with shallow topsoil. Establishing legumes with minimal tillage will help rejuvenate the hilly pastures.

The farm has a layered limestone pasture that does not allow for conventional seeding techniques. The seeding methods used in this project include frost seeding, light tillage (drag) and animal impact.

Intensive rotational grazing (IRG) of beef cattle will help improve forage productivity. The Gundersons will evaluate several legumes to see which are best adapted to these soils, including: birdsfoot trefoil, red clover, vernal alfalfa. Lush forage growth will help reduce soil erosion.

The Gunderson's goal is to improve the productivity of their pasture so that they could increase the number of cattle in their herd.

Project Results

The Gundersons erected a new perimeter fence and a second fence 16' inside the perimeter fence which created a lane. The pasture was divided into 10 paddocks. Two of the paddocks were seeded with white and red clover and vernal alfalfa. In one paddock the legumes were frost seeded and the other was dragged for light incorporation of the seed.

Observations

Frost seeding was a very easy and reliable way of seeding legumes. Also, the cows were more content when they were moved to fresh grass more often. Pasture capacity (stocking rate) for cows increased.

Economic Analysis of Gunderson's IRG Project in 1992 Season

Number of Acres in IRG pasture	15
Number of acres grazed continuously	17
Total acres in gross margin analysis	32
Number of paddocks within IRG area	10
Type of livestock	beef
Total number of animals on pasture	15 cow/calf pairs
Stocking rate per acre:	1.2
Date animals began grazing in 1992	5-5-92
Date animals stopped grazing in 1992	11-20-92
Total number of days out on pasture	196
Estimated labor: time/day	1 hour
Productivity on Pasture (Efficiency Factors)	
% Calf crop	83
Gross Profit ($) from Pasturing Acres	
Beef Sold	3000.00
Total Gross Profit	**3,000.00**
Gross Profit/Acre	**93.75**
Variable Costs (Out-of-pocket Expenses)	
Pasture Expenses	
Seed costs	50.59
Fertilizer	10.00
Total Pasture Costs	60.59
Total Variable Costs	**60.59**
Variable Costs/Acre	**4.04**
Gross Margin/Acre	**89.71**
(Gross profit/acre - Variable costs/acre)	

Gross Margin represents the amount left over to pay for fixed/overhead costs (in this case that includes fencing and water pipes), labor and management, living and family expenses, etc.

Location of Project

From downtown Northfield, take 4th street east to end. Take a left. You will be on Wall Street Road (also called 90th St. E.); go about 4-1/2 miles then the black top will turn to gravel road; 3rd place on left side of road on gravel.

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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	*Enter-prise*	beef feeders, beef cow/calf, native prairie pasture

Project Description

Rotational grazing (RG) offers a number of environmental and economic benefits. It allows for a higher stocking rate per acre which increases the potential profit per acre. More attentive management of animals in this system allows grasses to grow more evenly without being grazed off which reduces soil erosion. Manure is managed by the animals themselves because as they graze, they spread their manure evenly through the fields to fertilize the soils. Native grasses can be maintained rather than eliminated.

The animals will feed on weeds, which cuts herbicide usage. By decreasing fertilizers and herbicides usage, and by not allowing manure to accumulate, 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 an initial purchase of fencing and requires more intensive management than continuous grazing. But this system - which improves animal and forage productivity - has great potential to increase farm profits.

Project Results

Four farms cooperated in this project and achieved varying degrees of success.
AUE = Animal Unit Equivalent = 1,000 lbs
AUD = Animal Unit Days = (AUE) x (# days)
AUM = Animal Unit Months = AUD/30 days
ADG = Average Daily Gain

1992 Season

The cool and wet conditions this year made it more of a challenge to manage beef under rotational grazing systems.

Buschena Farm

1990 Observations

This beef cow/calf operation grazed from May 28-Oct. 1, 1990. In addition to providing forage for the grazing livestock, pastures in rotational grazing system produced 16 tons of grass hay. Calves gained 277 lbs/A.

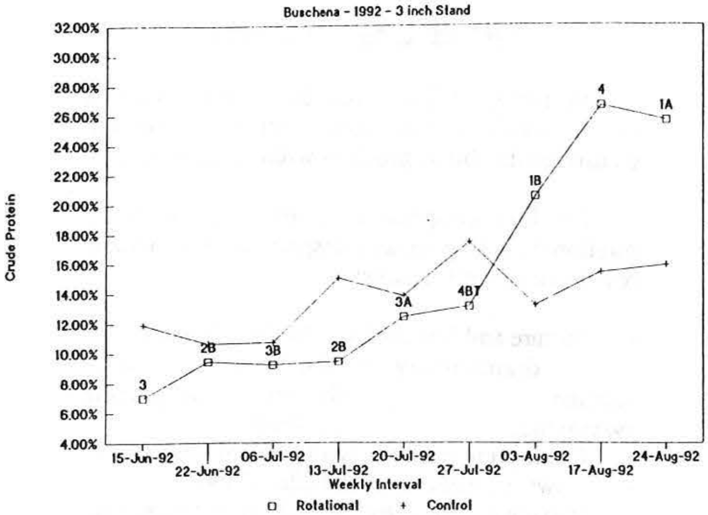
1991 Observations

Cattle were out in the pasture two weeks earlier than previous year. Stocking rate on rotational pastures was increased by 35%, yet ADG of calves was maintained. Hay harvest, however, was reduced. The crude protein of the pasture forage in August was analyzed to be 30%. Calves in rotational pastures required less creep feed.

Buschena Farm
Continuous vs. Rotational Grazing (RG)

	Year	Contin.	RG
AUM/A	1990	6.0	5.1
	1991	6.6	10.2
	1992	6.7	8.5
ADG	1990	2.4	2.6
	1991	2.5	2.5
	1992	2.2	2.3
Creep feed	1990	0	0
$/A	1991	42.94	32.21
	1992	42.94	32.21
Return	1990	67.29	63.71
$/A	1991	34.35	83.04
	1992	35.65	52.63
Calf Gains	1990	307	277
lb/A	1991	367	477
	1992	317	325

Crude Protein Comparison



Ebbinga Farm

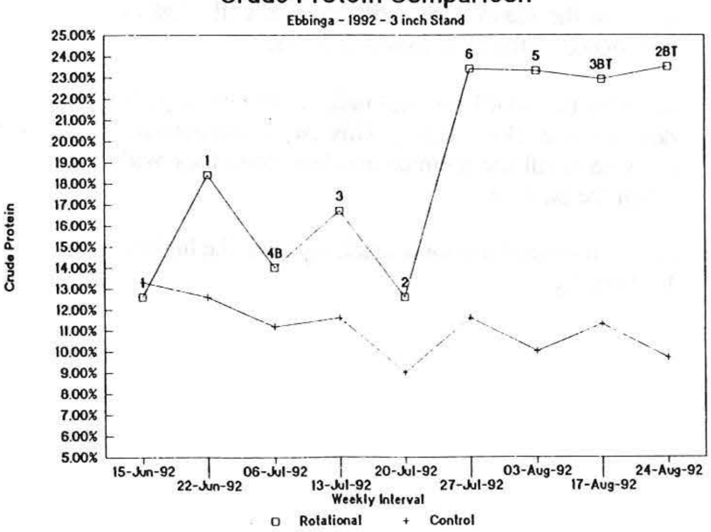
1990 Observations

Ebbinga beef cow/calf operation grazed from June 10-Oct. 22, 1990. Also harvested 8 large round bales of hay from rotational pastures. Cows were in better condition, cattle were easier to handle, and greater diversity of grass species grew in RG pastures.

1991 Observations

Enough surplus hay was harvested from RG pastures to provide forage for almost 90 days after cows were off pasture, which suggests that the RG pastures could have been stocked at a higher rate (more animals). The control (continuous) group of cows were on better ground than the rotational grazing group. The stocking rate was thus higher in the control group. Calves in rotational pastures required less creep feed.

Crude Protein Comparison



Ebbinga Results

	1990		1991	
	Contin.	RG	Contin.	RG
AUM/A	5.6	3.8	6.9	4.2
ADG	1.5	1.5	1.9	1.9
Return $/A	64.64	33.16	52.04	33.76
Calf Gains lbs/A	189	122	270	165

Burke Farm

1990 Observations

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

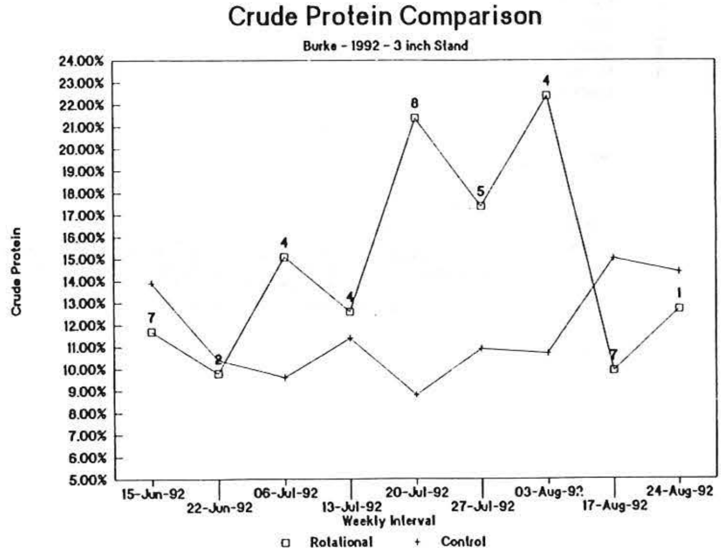
1991 Observations

Did a much better job of managing the pasture this year. Redesigned layout of paddocks to better utilize the grass. Doubled the amount of cows in the rotational group, yet maintained the Average Daily Gain. Calves in rotational pastures required less creep feed.

Burke Results
Continuous vs. Rotational Grazing (RG)

	Year	Contin.	RG
AUM/A	1990	5.4	3.6
	1991	4.6	6.3
	1992	4.8	4.2
ADG	1990	2.2	2.4
	1991	2.0	1.9
	1992	2.0	2.2
Return $/A	1990	66.34	33.70
	1991	17.47	42.17
	1992	20.40	6.69
Calf Gains lb/A	1990	240	177
	1991	194	255
	1992	182	192

Crude Protein Comparison



Smeins Farm

1990 Observations

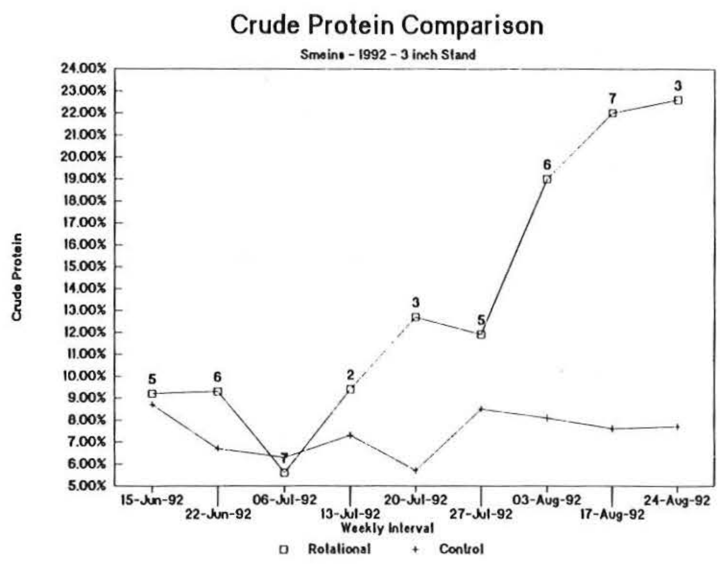
Smeins dairy calf operation harvested 9 round bales of grass in rotational pastures. Weekly tests for pasture quality showed an average of 16% protein, and was as high as 23% protein.

1991 Observations

Calves pastured from end of April to first of November. Erratic rainfall made pasture management more of a challenge. Rotational grazed pastures were under-stocked, which reduces profits. The Smeins overall are pleased with rotational grazing system because of improvement in herd health.

Smeins Results

	1990		1991	
	Contin.	RG	Contin.	RG
AUM/A	2.7	3.5	4.5	5.7
ADG	0.82	1.0	1.3	1.3
Return $/A	23.46	-6.46	25.52	-10.54
Calf Gains lbs/A	179	316	230	491



Other Observations

In 1990, Ebbinga and Burke pastures had severe thistle infestations. Rotational grazing controlled the thistle problem without herbicides.

All four cooperators were happy with the rotational grazing system despite mixed economic results for several reasons:

- Pasture and livestock productivity improved dramatically as the farmers learn to manage the rotational grazing system more skillfully.
- Cattle were easier to work with in this system.
- Cows appeared to be in better shape.
- It was easier to detect when beef cows were in heat in rotational grazing system.
- Dairy calves were more content.
- Different species of grass started to appear and grass growth was more lush.
- The farmers all agreed that "The system works once you figure out what to do."

Management Tips

a. Manage the quality of the grass to the class of livestock, i.e. cows versus yearlings, sheep versus cattle, beef cows versus dairy calves.

b. Depending on the type of grass, harvest early enough in the grazing season to insure good quality hay and to insure adequate regrowth for later grazing. i.e. cut the hay right after you harvest your first cutting of alfalfa.

c. With cool season grasses, the stocking rate in the early part of the grazing season can be higher. Later in the season, the stocking rate will need to be reduced as the forage growth slows.

d. Use the AUM (animal unit month) concept to determine stocking rates. This takes into account the size of all the animals and how long they will be on the pasture.

e. Tall grass does not necessarily have the highest feed quality.

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

Project Description

Rotational grazing of sheep and ewes on pasture improves animal and pasture productivity, farm profitability, and eliminates soil erosion on this hilly, highly erodible southeast Minnesota farm. Sheep remain on pasture for 8 months in an intensively managed operation. This project also demonstrates pasture renovation with birdsfoot trefoil.

Project Results

Pastures are a mix of birdsfoot trefoil, red and white clovers, bluegrass, quackgrass, brome, orchardgrass and timothy.

Summary of Grazing Data of Ewes

	1992	1991	1990
Number	70	65	62
Grazing Days	245	255	240
Total lbs Gain	16.5	18.5	18.0
Gain per Day - lbs	.066	.084	.085
lbs lambs weaned per ewe	94.9	91.8	91.4
lbs lambs marketed per ewe	202*	169.8	167.0

*Ewe lambs were sold in '92 at a heavier weight than in 90-91.

Summary of Grazing Data of Lambs

	1992	1991	1990
Number	125	104	124
Animal Grazing Days	17,849*	8,099	10,955
Average Daily Gain	.421	.577	.453
Daily Gain-Supplements	.238	.256	.142
Daily Gain-Pasture	.183	.321	.310
lbs Gain per Acre	655	744	850

*Higher number than 90-91 because ewe lambs grazed longer before being sold.

Observations

Coccidiosis, which had been a problem in previous years, was under control this year probably due to the weather and to preventive measures.

Although there is a heavy coyote population in this area, electric fences have been very effective in controlling predators and there have been no sheep losses.

Heavy fall and winter grazing of birdsfoot trefoil pastures (BTF) by the ewe flock in '91 stimulated forage production presumably because forage seeds were trampled and packed into the soil. Early grazing (late April/early May) also did not harm BTF, which set a heavy seed crop in their second growth. An attempt to harvest a seed crop from a 12 year-old BTF was unsuccessful because it had not been grazed before it was cut in August. As a result, the vegetative growth was too long and heavy to be combined. In the future, McEvilly plans to have the BTF grazed early spring and then harvest in August.

Allowing the BTF to stockpile reduces feed quality and lowers the weight gain of lambs on pasture. However, the nutritional value is ample for ewes through early gestation.

Environmental Benefits

- There was no observed erosion on fields classified as highly erodible.

- Soil tests confirm pasture fertility maintained by rotational grazing. Pasture longevity increased by IRG.

- Alfalfa hay land chemical free for 4-1/2 years, and kept productive after 6 years with annual applications of composted sheep manure.

- Reduced use of petroleum fuel because:
  a. Pasture renovated by no-till, frost seeding, animal trampling, and stockpiling.

Gross Margin Analysis of McEvilly's 1992 Intensive Rotational Grazing Project

Number of Acres in IRG pasture	23
Number of paddocks within pasture area	70
Type of livestock	sheep
Number of animals on pasture	195
Stocking rate per acre:	1.1 animal
8.5 head/acre	units/A
Date animals began grazing in 1992	4-19-92
Date animals stopped grazing in 1992	12-19-92
Total number of days out on pasture	245
Estimated labor: time/day	45 minutes
Tons of hay baled/chopped off pasture	18 T
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head)	ewes - 0.61
	lambs - 0.42
Lambing rate of ewes[1]	E.L.- 100%
	M.E. - 200%
Gross Profit ($) from Pasturing Acres	
Market lambs sold	4553.47
Breeding stock sold	6190.00
Wool sold	982.68
Culls sold (23 aged ewes)	805.00
Hay from pasture: 18 T @ $90/T	1620.00
Total Gross Profit	**14,151.15**
Gross Profit/Acre	**615.26**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Corn	740.00
Concentrates	850.00
Mineral/Salt	98.00
Total Purchased Feed Costs	1688.00
Livestock Costs	
Veterinarian/Medicine	140.00
Total Livestock Costs	140.00
Pasture Expenses	
Seed costs	65.00
Total Pasture Costs	65.00
Operating Expenses for Pasture	
Electricity	25.00
Supplies	627.00
Fuel costs	35.00
Repair costs (building and equipment)	85.00
Labor costs (seasonal only)	800.00
Livestock Hauling	120.00
Other costs: Rentals	125.00
Total Operating Expenses	1817.00
Total Variable Costs	**3710.00**
Variable Costs/Acre	**161.30**
Gross Margin/Acre[2]	**453.96**
(Gross profit/acre - Variable costs/acre)	

[1]E.L.=ewe lambs, M.E.= mature ewes; [2]Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.

b. Animals harvest own feed for 8-1/3 mth/yr.
c. Barn cleaning and manure hauling less 1/2.
d. No pesticides or chemical fertilizers used.

• Healthier livestock with longer productive life-spans. Ewes commonly productive for 10-11 years.

• Abundant and diverse wildlife population: deer, pheasants, wild turkeys, grey partridges, ruffed grouse, hawks, owls, myriad songbirds, woodpeckers, nuthatches, coyotes, rabbits, squirrels and gophers.

Highlights from 1991

1. Parasite prevention and management are critical in pasturing lambs, especially in wet years. Despite aggressive worming and coccidiosis treatment, lambs were taken off pasture several times during the season which required more supplemental feed.

2. Pasture improvement by no-till seeding of legumes into grass pastures has been very successful and economical. When seeding legumes, inoculating seed with appropriate nitrogen-fixing bacteria helps plants to establish.

3. Allowing BTF pastures to go to seed once every two years, preferably in June, helps maintain vigor of stand while providing decent pastures for late summer to winter grazing.

4. Pasture fertility and weed control is readily maintained through controlled grazing.

5. Clipping or spraying forage underneath electric fence lines several times during grazing season helps prevent problems with low voltage. Birdsfoot trefoil, especially when stockpiled, grows very long and lodges, grounding out the bottom wires and short-circuiting the power.

6. Net return/acre in this system for lambs was $593 (@ $0.85/lb of lamb - average price received from breeding stock, locker lamb, and market lamb sales).

7. Feed costs/lb of gain was estimated to be $0.257, which was somewhat inflated because lambs were taken off pasture for worming and coccidiosis treatment.

8. Est. labor requirement. In the spring with ewes and lambs together and all perimeter fences and lanes in place from previous year, 1/2 hour per day required for moving animals and fences. Time spent moving animals and fences after weaning (with ewes and lambs in separate pastures, including time spent walking to pastures) was 1-1/2 hours every 2 days.

9. Ewes grazed from April 20, 1991 to January 1, 1992.

Highlights from 1990

This productive ewe flock of 65 heads (203% lambs weaned/ewe lambing) was put onto legume/grass pasture on April 28th with the young lambs on a controlled grazing program. 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

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, locker lamb, and market lamb 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 240 days (from April 28 to December 22).

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 22 from that pasture.

5. Sixteen (16) tons of hay was also harvested from pasture.

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 (use more wires) than you need for cattle. Train the sheep to the fence when they are in short fleece.

4. Parasite control on pastures is important.

5. Add legumes to your grass pastures; birdsfoot trefoil works well because of its longevity and non-bloating qualities.

6. Start grazing as early in the year as possible and move fast. If you cannot keep abreast of pastures by grazing, hay the surplus forage - or in the case of birdsfoot trefoil, stockpile it for late summer, fall, or winter grazing.

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. McEvilly keeps 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, McEvilly allows each paddock to be grazed 3-4 times/summer.

12. Attend rotational grazing workshops and field days and observe how others have their systems set up; no two farms are alike, but you may see some things that would work for you.

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Project Title:	**A Comparison Study of Intensive Rotational Grazing vs Dry-Lot Feeding of Sheep**	*Time Span:*	April 90 to December 92
Principal Investigator: Address	R & K SHEPHERDS 61231 MN HWY 7 Hutchinson, MN 55350	*Tel:* *County:*	612-587-6094 Meeker
Cooperators:	Doug Rathke Connie Karstens	*Enter-prise*	pasture, forage, sheep

Project Description

This project compares pasture feeding lambs under an intensive rotational grazing (IRG) system to conventional dry lot feeding of sheep in terms of time, effort, nutritional value of feed, health and parasite problems, body condition, and most importantly, overall cost per animal.

The specific objectives were as follows:

•To increase the number of animal units per acre beyond the standard pasture growing season by at least doubling plant productivity.

•To match the quality and quantity of feed stuffs to meet the nutritional needs of sheep during various stages of production while reducing feed costs and ultimately increasing profit.

•To show both direct and indirect energy savings with reduced hay making and the use of natural (sheep-made) fertilizer and minimal insecticide.

•To reduce the long-term labor unit hours per animal.

•To produce a higher quality product (lamb & wool) that are produced largely from renewable resources and in harmony with the natural environment.

Project Results

Rathke and Karstens used two different groups of sheep for the comparison study. The control group was fed out on dry lot and the experimental group was managed on pasture under an intensive rotational grazing system.

A 12-acre pasture was divided into 16 3/4 acre paddocks and planted in birdsfoot trefoil, white clover, timothy, brome, and orchard grass. A comparison of feed costs, average daily gain, parasites, carcass quality and fleece condition was conducted. Also, a study of soil improvement was tested throughout the project.

In 1991, they added a group of lambs, separate from the ewes, to their grazing project. The lambs grazed ahead of the ewes. Also in the lamb group were lactating ewes with their lambs. The ewe group, which followed behind, acted as a clean up crew. Another change they made was that after the first two years, they eliminated the dry-lot fed control group because it was not economically feasible. Although Karstens and Rathke did not use a pasture probe to measure forage productivity, they were able to estimate forage produced through observation of plants and animals. The third year of the project, they made use of additional land for fall and winter grazing with their 15 acre alfalfa field.

Observations

After 3 years of managing livestock under an IRG system, Karstens and Rathke are convinced that IRG maximizes profits as well as both animal and plant productivity and quality while minimizing labor, animal stress, and health problems

1. Grazing season was extended beyond the traditional season. Sheep grazed for 8.5 months out of the year.

2. Pasture fed lambs gained an average of 0.61 lbs/day with the select ones as much as 0.82 lbs/day.

3. Fleece condition was cleaner, brighter, and higher yielding (est. yield over 60%).

4. Pasture spring lambing was measurably easier, more efficient, less labor intensive. Also, lamb

vigor and health appeared to improve over winter lambing.

5. The amount of labor to raise the livestock under IRG is less than under conventional system. However, IRG requires better management skills, more thinking, and more planning.
6. Carcass results were analyzed as follows: (for pasture fed lambs):

112 lb. live weight lamb
60 lbs carcass -- 54% dress weight
Kidney Pelvic Fat was visibly less
Back Fat Reading of 0.14
Loin Eye = 2.8 (above average)

Pasture fed lambs are considerably leaner than dry lot lambs.

7. IRG system reduces feed costs of raising sheep.

8. Soil organic matter has increased by more than 1/2% from 1990 to 1992 under IRG system.

Soil Tests Comparisons from 1990 when IRG was initiated to 1992

	1990	1992
Organic matter	3.1%	3.8%
pH	6.9	7.4
	% Base Saturation	
K	1.4	2.4
Na	0.3	0.2
Mg	20.4	15.3
Ca	77.9	81.9

Performance of IRG compared for Dry lot feeding over a 3-yr period (1990-92)

	ADG	Body Condition *	Ewe Feed Cost	Lamb Feed Cost
1992				
Dry Lot	N/A	3.0	$66.69	$23.00
IRG	0.61	4.0	$25.00	$7.00
1991				
Dry Lot	0.83	2.5	$30.86	$20.30
IRG	0.50	4.0	$21.81	$6.40
1990				
Dry Lot	N/A	3.0	$29.69	No data
IRG	N/A	4.5	$14.74	No data

*Body condition based on a 1-5 scale.

Gross Margin Analysis is a useful tool for evaluating the profitability of the pastures on a *per acre* basis. *Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.*

Gross Margin Analysis of Rathke and Karstens IRG Project for 1992

Number of Acres in IRG pasture	12[1]
Number of paddocks within pasture area	16
Type of livestock	sheep
Stocking rate per acre: 100 lambs + 67 ewes	1.45 animal unit/A[2]
Date animals began grazing in 1992	4-5-92
Date animals stopped grazing in 1992	12-6-92
Total number of days out on pasture	241
Estimated labor: time/day	10 minutes
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head)	0.61
Lambing rate of ewes	218%[3]
Gross Profit ($) from Pasturing Acres[4]	
Market lambs sold (66 head sold @$75/ea.)	4953.40
Breeding stock sold	500.00
Wool sold	851.93
Culls sold	233.00
Breeding stock retained for replacements (34 head @ $150.00)	5100.00
Total Gross Profit	**11,634.33**
Gross Profit/Acre	**969.86**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Corn[5]	1199.49
Mineral/Salt	60.85
Forage[6]	442.50
Total Purchased Feed Costs	1702.84
Livestock Costs	
Bedding	268.00
Veterinarian/Medicine	201.00
Total Livestock Costs	469.00
Pasture Expenses	
Seed costs	21.88
Fencing (20 yr. depreciation)	232.05
Total Pasture Costs	253.93
Operating Expenses for Pasture	
Electricity, utilities and insurance	83.75
Supplies	81.00
Fuel Costs	20.00
Repair costs (building and equipment)	150.25
Total Operating Expenses	335.00
Total Variable Costs	**2760.77**
Variable Costs/Acre	**230.06**
Gross Margin/Acre[7] *(Gross profit/acre - Variable costs/acre)*	**739.80**

[1]0.75 acres were not used because of renovation - re-seed with trefoil; [2](Total # of head) x (Ave. Wt.) + (1000 lbs) + (# of Acres); 3Accelerated lambing program; [4]With accelerated program, not everything produced (wool & lambs) in 1992 was sold in the same year; [5]Corn was purchased in 1992, but some will be used in 1993; [6]Most of the hay will be used in 1993; [7]Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.

The accelerated lambing program that Rathke and Karstens used made it difficult to get exact figures for the gross margin analysis. The constantly changing stocking rate allowed Rathke and Karstens only to make best-guess estimates of profits and expenses incurred during the calendar year.

Highlights from 1990

1. Feed costs were reduced 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. The capacity of the pasture was increased to graze a higher number of sheep per acre.

Highlights from 1991

1. Lambs rotated to new paddocks every 2 days, ewes followed and rotated every 3 days. An additional 27 fall lambs were also pastured for a total of 116 sheep.

2. Six acres of hay were harvested twice, producing 350 bales. Grazing ended on Nov 28 due to poor weather, for a total of 225 grazing days.

3. Animals appear to be less stressed under rotation grazing system. They did not have to crowd at feeders and compete for food.

4. Cocklebur problem solved simply by allowing animals to graze; no chemicals applied. No fertilizers or pesticides used in this system.

Management Tips

1. Due to the extensive rainfall during the 1991 season, white clover grew so profusely that it could have inhibited other forages such as birdsfoot trefoil. White clover planting should be reduced from 2 lb to 1/2 lb/A.

2. After grazing a paddock, mowing the weeds will help reestablish the desirable forages.

3. The rotation of the paddocks should 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.

4. Make additional pasture available for use when paddocks need a greater rest period. Rathke and Karstens made use of other areas when the grass was not growing back as quickly as anticipated. This helps prevent over-grazing damage to the pasture.

5. Alternate the usage and order of paddocks from season-to-season or year-to-year to maximize forage production.

6. Making a water source available in each paddock works better than having the animals return to just one water source a distance away.

7. Attending field days and visiting with other graziers helps you gain a better understanding of the concept and potential of IRG.

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.

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Project Title:	**Winter Grazing Study**	*Time Span:*	September 91 to May 93
Principal Investigator: *Address*	Janet McNally and Brooke Rodgerson Box 63, Rt. 2 Hinckley, MN 55037	*Tel:* *County:*	612-384-7262 Pine
Cooperators:	Kelley O'Neil - Sheep Producer, Bloomington, MN Robert Margress - Beef Producer Roger Thompson - Farm Management Instructor,Pine Tech.	*Enter-prise*	sheep

Project Description

Livestock producers in the Midwest began experimenting with intensive rotational grazing by putting their animals out in pasture paddocks during the warmer months. As producers see the benefits of summer grazing in terms of environmental improvements, increased animal and forage production and higher profits, many want to expand this system of livestock production.

Ordinarily, lambs are on pasture from late spring until September. Lambs are finished on drylot feed while ewes continue grazing until snowfall. By November, ewes are removed from the pasture and are fed hay until mid-May. By extending the grazing season into winter, feed and fuel costs can be reduced increasing profits for the producers.

This project explores strategies to raise late spring lambing ewes on winter pasture including winter stocking rates, suitable winter forage species, winter grazing management. Grazing behavior and animal welfare will also be examined. Winter grazing is defined as the pasturing period between November 1 through April 30. The study focuses on sheep managed on an April or May lambing schedule, but will also provide some information on February and fall lambing ewes as well.

Highlights from 1991

Rodgerson Farm

Pastures stockpiled:

8 acres timothy, brome, alfalfa - hayfield since Aug. 15
8 acres turnips - planted Aug. 1st
8 acres rye grain - planted Aug. 12th
8 acres timothy, brome, clover - hayfield since Aug. 15th
5 acres lightly wooded native pasture

These pastures were grazed by 115-140 ewes from Nov. 1 - Nov. 30 and from March 4 through lambing (beginning April 18th). Big round bales of hay provided feed from December through February. Small bales of high quality hay and corn were provided as supplements to ewes during March and April.

McNally Farm

Pastures stockpiled:

12 acres orchardgrass and ladino clover - hayfield since Aug. 15th
12 acres very mature bluegrass (not grazed in 1991)

These pastures were grazed by 85 ewes from Nov. 1 - Dec. 4 and from March 6 through lambing (beginning May 8th). Big round bales of hay provided feed from December through February. Small bales of high quality hay and corn were provided as supplements to ewes during March and April.

Despite an early winter (30" snow on Oct. 31, and 26" in Nov.), the sheep grazed for 75 days between Nov. 1, 1991 and April 30, 1992 on McNally's farm. Twenty days of grazing were without any supplemental feed. Grazing provided roughly half the forage for the other 55 days of grazing. Rodgersons achieved 76 days of grazing during the same period, 37 days with no supplement and the remainder 39 days grazing provided half of the forage. In both cases, 20 days of grazing occurred between Nov. 9 and Nov. 30. The remaining grazing began after a major snow melt March 4-6. Between Nov. 30 -Mar.4, the pasture remained under a 12-24" snow pack that was too hard and crust for sheep to dig through.

On both farms, sheep obtained all their nutrient needs in the fall from pasture, while they were still open (not bred) and thus requiring only a maintenance diet. In March ewes entered late pregnancy so they were fed up to 1.36 lbs/head of corn. They fed on good quality hay, which provided half of their forage, in March and April.

Forage Quality

Forage tests on most fields revealed that feeds were equivalent to #2 or #3 alfalfa hay in quality except for the mature bluegrass which was more similar to #5 and presented intake problems.

Grazing in Snow

Sheep readily grazed through 6-8" of soft snow. After the snow storms of Oct 31st and Nov 30th, sheep grazed through 12-18" of soft snow for short periods of time. At 12-18" snow depth, the sheep might only be able to eat enough for survival. Snow conditions such as hardness and crustiness provided a bigger barrier to grazing than did snow depth.

Condition Score and Body Weight Gain

Condition score, body weight gain, lambing percentage, and lamb survival to one week old are used as measures of progress.

McNally Farm
Weight Gain (lbs) of Ewes in Full Fleece
between 10/27/91 and 4/4/92

Age	Begin Wt.	End Wt.	Ave. Gain
Yearling	104	120	16
2-year	120	138	18
Mature	140	153	13

Average Condition Score

2.016 on Oct. 27
2.871 on April 4
(5 weeks before lambing)

Rodgerson Farm
Weigh Gain (lbs) of Ewes *
between 11/13/91 and 4/17/92

Age	Average Gain
Ewe Lambs	16 lbs
Yearling Ewes	15 lbs
2 year	18 lbs
Mature Ewes	5.25 lbs

Labor Savings on Winter Pasture

Daily chores of caring for sheep on winter pasture are virtually nil. If no snow cover is present and the forage is dry, water will be needed. The guard dog needs to be fed, and the sheep mineral/salt checked. The only real work to winter grazing is created by the need to move portable fencing. Installation of permanent fencing can save on labor, but portable fencing allows for flexibility to stock pile forage in places that were not grazed in the summer or fall, thus allowing the livestock to spread manure and fertilize the area while grazing on the forage in the winter. Thus, portable fence may be an important part of a winter grazing plan.

Feed and Cost Savings for Winter 1991-92

	# bales*	$/bale	Total Saved
McNally	302	1.40	$423
Rodgerson	447	1.75	$782

*Number of bales of forage saved due to winter grazing compared to what the sheep consume under winter confinement.

Cost Analysis [1] of Winter Grazing and Conventional (Hay Fed) System

	Hay Feeding	Winter Grazing
Value of hay crop in field	$190 to $270[2]	$180[3]
Power and Machinery costs of making hay	$210*	$0
Fencing	$0	$120 portable[4]
Labor	45 -75 hours[5]	15 - 42 hours
Cash costs per 100 ewes	$400 - $480	$240 - $300
Labor costs	$450 - $750	$150 - $420
Total costs per 100 ewes	$850 - $1230	$390 - $720

[1] Cost of feeding 100 ewes for 60 days in the winter.
[2] $15 to $24 per 1200 lb bale minus power and machinery costs. Estimated intake of 3.5 lbs dry matter/ewe.
[3] $.03/ewe - Land lease rate for McNally.
[4] It may be inappropriate to charge fence against winter grazing if portable fencing is used for summer rotational grazing. Expected fence life: 8 years.
[5] Includes cutting, raking, baling, unloading and feeding hay. Total: 0.625 hours/acre.

*Adapted from 1991 Annual Report Northeast and East Central Minnesota Farm Business Management. Includes cost of owning equipment, which is incurred anyway if flock owner makes his/her own hay.

A minimum of 60 days of grazing should be feasible in almost any year between Nov. 1 and April 30, with 100 days of grazing quite feasible in years that are more "normal". This analysis shows that the greatest savings occurs in labor and power/machinery costs, when sheep are grazed instead of fed hay.

** Contact Rodgerson or McNally for information on animal behavior and winter grazing management.

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Project Title:	**Research and Demonstration of Rotational Grazing Techniques for Dairy Farmers in Central, Minn.**	*Time Span:*	January 90 to December 92
Principal Investigator: *Address*	Bob Stommes Stearns County Extension Office 2700 First St. North #205 St. Cloud, MN 56301	*Tel:* *County:*	612-255-6169 Stearns Benton Wright Sherburn
Cooperators:	Farmers: Joe and Tom Molitor, St. Cloud; Ralph Klassen, Belgrade; Ervin Kerfeld, Melrose; Duane Brenny, Rice; John Merdan, Avon.	*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 intensive rotational grazing (IRG), 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 be necessary.

Animal manures provide the nutrients for fertilization. While they are grazing in a paddock, they spread their waste uniformly in the area. Energy inputs are also reduced. The fuel 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 examines intensive rotational grazing systems for dairy farmers in Central Minnesota.

Highlights from 1990

Three dairy farmers participated in this first year of the project. Fences were purchased and rotational grazing systems were installed on two farms.

Molitor Farm

The Molitors put 90 heifers onto some existing pasture/hay land for rotational grazing. In addition to grazing, they fed the heifers 24 lbs of corn silage and 1.5 lbs of concentrated feed . The heifers gained 1.85 lbs/day for the 150 days on pasture.

IRG vs. Conventional Management (CM) of Dairy Heifers on Molitor Farm (1990)

	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

Lactating cows grazed 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

Kerfeld 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 had 90% to 100% stand.

Forage Value of Pasture Hay 1990

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

*per cent of dry matter

Highlights from 1991

Four dairy farmers participated in 1991 on this demonstration project.

Summary of Results of Rotational Grazing of Dairy Cattle in 1991

Name	Livestock number	Grazing Days	Number of Acres Grazed	Net Profit Per Acre*
Brenny	42	100	10	$517
Klassen	34	154	21	$265
Molitor	85	34	18	$128
Kerfeld	43	77	26	$271

*Net Profit gained from intensive rotational grazing compared to conventional feedlot system.

Analysis of Profitability

Calculation of net profit from IRG system compared to feedlot system was based on the amount of dollars saved in feed costs (including cost of corn silage, haylage, hay, grain, protein, mineral, and bedding) during rotational grazing period (total number of days on pasture) for each cow per acre grazed. The estimates reported take into account the cost of grazing, which includes: cost of seed, fuel, fencing (depreciated over 5 years) and water system.

Comparison of Cost to Produce 100 Cwt. Milk

Name	Confinement System	Rotational Grazing
Molitor	$3.61	$2.87
Brenny	$3.08	$2.77
Kerfeld	$4.01	$2.26

Forage Quality of Pasture

Forage tests were taken at various times throughout the grazing season to evaluate forage quality.

Forage Quality Test Results for 1991
(Low and High Range)

	% Crude Protein	ADF (%)
Molitor	16.4 - 23.2	24.0 - 35.8
Kerfeld	17.1 - 22.9	28.8 - 36.0
Klassen	12.8 - 23.9	25.1 - 43.7
Brenny	20.6 - 26.9	24.1 - 41.1

Highlights from 1992

A Gross Margin Analysis was made to evaluate the profitability of IRG on each of the participating farms. The gross margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.

Gross Margin Analysis of Molitors' 1992 Intensive Rotational Grazing Project

Number of Acres in IRG pasture	97
Number of paddocks within pasture area	27
Type of livestock	heifers and dry cows
Number of animals on pasture	116 (varied)
Stocking rate per acre:	1.1 animal units/A
Date animals began grazing in 1992	4-23-92
Date animals stopped grazing in 1992	9-23-92
Total number of days out on pasture	170
Estimated labor: time/day	30 minutes
Tons of hay baled/chopped off pasture	34T
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head) (Range 1.5 - 2.5)	2.04
Gross Profit ($) from Pasturing Acres	
Weight gain of cows valued at $.80/lb	40,228.80
Total Gross Profit[1]	**40,228.80**
Gross Profit/Acre	**414.73**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Corn	360.00
Mineral/Salt	700.00
Total Purchased Feed Costs	1060.00
Pasture Expenses	
Seed costs	50.00
Custom harvesting/baling forage	1200.00
Total Pasture Costs	1250.00
Operating Expenses for Pasture	
Electricity	5.00
Fuel costs	40.00
Total Operating Expenses	45.00
Total Variable Costs	**2355.00**
Variable Costs/Acre	**24.28**
Gross Margin/Acre[2] *(Gross profit/acre - Variable costs/acre)*	**390.45**

[1] Does not include value of 34 ton hay from IRG pastures.
[2] Gross margin earned on pasturing acres during pasturing season.

Gross Margin Analysis of Kerfeld's 1992 Intensive Rotational Grazing Project

Number of Acres in IRG pasture	26
Number of paddocks within pasture area	13
Type of livestock	dairy
Number of animals on pasture	45
Stocking rate per acre:	2.16 animal units/A[1]
Date animals began grazing in 1992	6-26-92
Date animals stopped grazing in 1992	9-23-92
Total number of days out on pasture	89
Estimated labor: time/day	1 hour
Tons of hay baled/chopped off pasture	43 T
Gross Profit ($) from Pasturing Acres	
Milk sales ($) off pasturing system	25,903.44
Calves sold ($)	1,134.78
Cull cows sold ($)	1,746.71
Total Gross Profit[2]	**28,784.93**
Gross Profit/Acre	**1,107.11**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Concentrates	1,616.40
Mineral/Salt	370.80
Total Purchased Feed Costs	1,987.20
Livestock Costs	
Milk Hauling	357.41
Veterinarian/Medicine	206.45
Breeding costs	364.00
Total Livestock Costs	927.86
Pasture Expenses	
Seed costs	10.00
Mowing weeds	2.00
Total Pasture Costs	12.00
Operating Expenses for Pasture	
Livestock Hauling	50.00
Total Operating Expenses	50.00
Total Variable Costs	**2,977.06**
Variable Costs/Acre	**114.50**
Gross Margin/Acre *(Gross profit/acre - Variable costs/acre)*	**992.61**

[1]Animal units = (Total number of animals) x (acerage weight) + 1000 lbs.

[2]Does not include value of 43 tons of hay from IRG pastures

Gross Margin Analysis of Klassen's 1992 Intensive Rotational Grazing Project

Number of Acres in IRG pasture	10.5
Number of paddocks within pasture area	3
Type of livestock	dairy
Number of animals on pasture	20
Stocking rate per acre:	1.82 animal units/A[1]
Date animals began grazing in 1992	5-3-92
Date animals stopped grazing in 1992	10-7-92
Total number of days out on pasture	158
Estimated labor: time/day	15 minutes
Productivity on Pasture (Efficiency Factors)	
Average daily gain (lbs/head):	1.89
(Bred holstein heifers: In 945# - Out 1,244#)	
Gross Profit ($) from Pasturing Acres	
Calves sold ($): $0.90 per lb gain	5,382.00
Total Gross Profit[2]	**5,382.00**
Gross Profit/Acre	**512.57**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Grain and Mineral/Salt	474.00
Forage	63.00
Total Purchased Feed Costs	537.00
Pasture Expenses	
Weed control - Clipping	21.00
Fertilizer	107.10
Other costs	118.20
Total Pasture Costs	246.30
Operating Expenses for Pasture	
Repair costs	100.00
Total Operating Expenses	100.00
Total Variable Costs	**883.30**
Variable Costs/Acre	**84.12**
Gross Margin/Acre *(Gross profit/acre - Variable costs/acre)*	**428.45**

[1]Animal units = (Total number of animals) x (acerage weight) + 1000 lbs.

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Gross Margin Analysis of Merdan's 1992 Intensive Rotational Grazing Project

Number of Acres in IRG pasture	17
Number of paddocks within pasture area	4
Type of livestock	dairy
Number of animals on pasture	44 (over 38 milking)
Stocking rate per acre:	3.5 animal units/A[1]
Date animals began grazing in 1992	5-15-92
Date animals stopped grazing in 1992	9-16-92
Total number of days out on pasture	122
Estimated labor: time/day	30 minutes
Tons of hay baled/chopped off pasture	12.5 T (500 bales)
Productivity on Pasture (Efficiency Factors)	
Amt of milk (cwt./cow) produced	7,351
Gross Profit ($) from Pasturing Acres	
Milk Sales ($)	38,098.42
Cull cows sold ($)	2,810.80
Calves sold ($):	785.00
Total Gross Profit[2]	**41,694.22**
Gross Profit/Acre	**2,452.60**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Corn	5,488.00
Total Purchased Feed Costs	5,488.00
Livestock Costs	
Milk Hauling	578.00
Veterinarian/Medicine costs	453.00
Breeding costs	507.00
Total Livestock Costs	1,838.00
Operating Expenses for Pasture	
Electricity	1.00
Labor costs (seasonal only)	300.00
Livestock Hauling	88.00
Total Operating Expenses	389.00
Total Variable Costs	**7,715.00**
Variable Costs/Acre	**453.82**
Gross Margin/Acre	**1,998.78**
(Gross profit/acre - Variable costs/acre)	

[1]Animal units = (Total number of animals) x (acerage weight) ÷ 1000 lbs.

[2]Does not include value of 12.5 tons of hay from pasturing acres.

Economic Analysis of Brenny's 1992 Intensive Rotational Grazing Project

Number of cows grazed	50
Number of days grazed	100
Bales of hay saved per day	10
Value of each bale of hay	$2.00
Savings per day	$20.00
Savings per year (100 days of IRG)	$2,000.00
Number of acres grazed	16
Savings per acre	$125.00

*Dry weather in June reduced forage yield

**Pasture management required 30 minutes per day.

Farmer Observations of Intensive Rotational Grazing System:

- Herd health improved, especially hoofs and legs, while on pasture.

- Grazing site selected should be close to buildings.

- Fresh, clean water must be available to the animals.

- Intensive rotational grazing system allows livestock to harvest hay and spread their own manure, reducing labor requirement for the farmer.

- Cattle should be put out to pasture early in the season to stay on top of the forage growth.

- Environmental benefits include reducing soil erosion, improving pasture productivity and yields, and reducing weed competition.

- As farmers gain more experience on how to manage these systems, there is great potential for improving animal and forage productivity.

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Project Title:	**Rotational Top-Grazing as a Method of Increasing Profitability with a High-Producing Dairy Herd**	*Time Span:*	May 92 to December 94
Principal Investigator: Address	Alton G. Hanson RR 3, Box 270 Pine City, MN 55063	*Tel:* *County:*	612-629-6423 Pine
Cooperators:	Steve Drazkowski - Pine County Extension Agent Jim Linn - Minnesota Extension Dairy Nutritionist Neal Martin - Minnesota Extension Forage Agronomist Tim Thompson - Nutra-Serve Nutritionist Others	*Enter-prise*	dairy, pasture

Project Description

In a rotational top-grazing system, only the top half of plants is removed during one pasture rotation. This system yields very high quality and quantity forage which allows the dairyman to reduce purchased inputs while maximizing milk production. The input costs, production levels, body condition and labor for a high-producing dairy herd in this grazing system were compared to those for a conventionally fed herd a previous year.

The specific objectives were:

- To provide high yielding, high quality pasture forage that will reduce grain and concentrate input costs while maintaining high milk production levels.
- To formulate balanced rations based on periodic pasture forage tests to maintain body condition for maximum milk production throughout the lactation.
- To use the cows to harvest the forage, fertilize the pasture, and control weeds which results in savings on costs of machinery, fuel, fertilizer and chemicals.
- To demonstrate savings due to healthier animals indicated by appearance, body condition, decreased vet costs and lowered somatic cell counts.

Project Results

Alton Hanson's Holstein herd began the project in 1992 with a 22,098 lb. rolling herd average on a 3 times/day milking schedule. A 20-acre pasture was divided into 5 four-acre paddocks using portable fencing to adjust paddock size to match growing conditions. Red clover was frost seeded into existing pasture which included June-blue grass, white clover, timothy, brome, and quack grass.

Improvement of the existing pasture, better management of the grass, forage analysis and ration balancing resulted in a dramatic reduction in purchased feed costs while high milk production levels were maintained. In 1991, the pasture was rotationally grazed but substantial amounts of purchased grain and concentrates as well hay supplemented the pasture. Prior to 1991, the pasture was continuously grazed.

Comparison of Production Level, Cost and Reproduction

Year Milking Schedule	1990 2x	1991 3x	1992 3x-2x
System of pasture grazing	Contin.	IRG	IRG
Number of cows	30	30	32
Pounds of milk	20183	22098	21186
% Fat	3.4	3.3	3.6
Total forage lbs (100% DM)	8347	9134	9186
Grain lbs (100% DM)	8458	7273	5888
Ave. Grain fed/cow/day	19.6	16.0	12.0
Ave. Protein Suppl. per cow/day	8.8	3.8	none
Milk per lb. grain DM	2.4	3.0	3.6
Feed costs /cwt milk ($)	6.55	5.28	4.10
Net farm income /cwt milk	4.20	4.83	4.95
Conception rate (%)	63	73	74

Forage quality, as well as quantity, was high throughout the grazing season. Paddocks were sampled from May through September. The averages and ranges across all pastures and sampling dates (59 samples) were:

	Average	Range
Calcium	0.95%	(0.39-1.40)
Phosphorus	0.32%	(0.20-0.44)
Potassium	2.23%	(1.16-3.74)
Magnesium	0.31%	(0.17-0.52)
%DM	22.60	(16.17-29.58)
%Moisture	77.40	(70.42-83.83)
Crude Protein	24.54	(16.16-34.81)
ADF	23.63	(16.50-31.31)
NDF	41.44	(29.17-53.64)
TDN	70.85	(65.41-77.67)
NEL	0.746	(0.631-0.828)
RFV	161	(119-239)

Gross Margin Analysis is a useful tool for evaluating the profitability of the pastures on a *per acre* basis. *Gross Margin represents the amount left over to pay for fixed/overhead costs, labor and management, living and family expenses, etc.*

Gross Margin Analysis of Hanson's IRG Project for 1992

Number of Acres in IRG pasture	49.6
Number of paddocks within pasture area	20
Type of livestock	Dairy
Stocking rate per acre: 32 dairy cows	.778 AU/A[1]
Date animals began grazing in 1992	5-3-92
Date animals stopped grazing in 1992	9-25-92
Total number of days out on pasture	145
Estimated labor: time/day	38 minutes
Tons of hay baled/chopped off pasture	69.5 tons
Productivity on Pasture (Efficiency Factors)	
Amnt of milk (cwt/cow) on IRG pasture	74.24
Gross Profit ($) from Pasturing Acres	
Milk sales from pasturing system	32,403.00
Cull cows sold	3227.00
Calves sold	1653.00
Value - hay baled off pasture ($60/ton)	4170.00
Total Gross Profit	**41,453.00**
Gross Profit/Acre	**836.00**
Variable Costs (Out-of-pocket Expenses)	
Purchased Feed Costs	
Corn	2017.00
Other Grain	442.00
Concentrates	33.00
Mineral/Salt	483.00
Forage	736.00
ZinPro, Niacin, Bi-Carb, LiqFat, Molas	625.00
Total Purchased Feed Costs	4336.00
Livestock Costs	
Milk Hauling	710.00
Bedding	108.00
Veterinarian/Medicine	587.00
Breeding Costs	894.00
Total Livestock Costs	2299.00
Pasture Expenses	
Seed costs	417.00
Fertilizer	331.00
Total Pasture Costs	748.00
Operating Expenses for Pasture	
Supplies	1018.00
Fuel Costs	150.00
Repair costs (building and equipment)	25.00
Labor costs (Seasonal only)	632.00
Livestock Hauling	89.00
Total Operating Expenses	1914..00
Total Variable Costs	**9297.00**
Variable Costs/Acre	**187.00**
Gross Margin/Acre	**649.00**
(Gross profit/acre - Variable costs/acre)	

[1] AU=(Total # of head) x (Ave. Wt.) ÷ (1000 lbs) ÷ (# of Acres);

Observations

1. The switch to rotational top-grazing resulted in an average work week of 42 hours, 6 hours per day. The Hansons calculated an hourly wage of $44.40 for the dairy operation before debt service, taxes and family living. This more relaxed lifestyle enables a farmer to take time to plan and look at new ideas that lead to a healthier farm operation.

2. Net profit per cow seems to be the more profitable concept rather than milk production. Balancing rations to changing pasture quality requires additional managerial skill and experience but can result in lower feed costs with higher profit per cow.

3. Low fiber level in the diet can be a problem when pasture quality is high. Cows craved hay while on high quality pasture.

4. While on pasture, cows were healthier and in good body condition which resulted in savings in veternary costs, drugs and breeding fees.

5. The environmental benefits of grazing included minimal use of purchased fertilizer, no pesticide use, almost no erosion with year round vegetative cover, minimal fuel usage ($150 for 49.6 acres), and excellent utilization of manure.

Management Tips

1. A cool, cloudy growing season with sporadic rainfall tests the managerial skill of the grazier.

2. Don't be foolhardy - grasp new ideas and mentally adapt them to your operation understanding that mistakes will be made but adjustments will correct them.

3. Read, attend field days and workshops, visit other graziers to exchange information.

Location of Project

Exit I-35 at Pine City. Go east at Pine City Exit on Hwy. 361 to street lights. Left on Hwy. 61 until you reach 4-way stop. Right to T. Right on Cty. Rd. 8. Left at Y on Cty. Rd. 9. Go 4 miles to Cty. Rd. 10 then east 2.25 miles. Farm is on north side of road.

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Project Title:	**Farrowing and Raising Pigs on Pasture**	*Time Span:*	Spring 92 to Spring 94
Principal Investigator: *Address*	Charles Cornillie Route 1, Box 57 Elbow Lake, MN 56531-9750	*County:*	Grant
		Enter-prise	diversified crops and livestock

Project Description

Conventional hog production requires high capital expenditures for housing, manure management, machinery, feed, and medication. Small-scale operators must find cheaper alternatives for raising hogs if they want to be profitable. One way to do so is to farrow and raise pigs on pasture by using portable housing and portable fencing. This project explores some low-input methods of raising hogs and how to use the pasture to supplement feed rations.

Project Results

In the first year of the project, Cornellie farrowed gilts in an old cow barn in 8' x 9' pens, and weaned 90 pigs from 11 gilts. Thirty (30) pigs were crushed by the sows because the open pens did not provide adequate protection.

He set up a low impedance electric netting fence on 8-9 acres. The pasture was no-till seeded with rape, which failed due to late-seeding. An earlier rape crop, planted in 1991, provided feed for the gilts.

Raising the pigs on pasture saves time for the producer compared to conventional confinement operation because there is no need to clean and dry the barns. Cornellie observed that the pigs were healthier on pasture and do not require sulfa drugs or other medication while on pasture. They do, however, need to be vaccinated and de-wormed. The pigs also require shade and plenty of water.

The pig pasture fits in well with a diversified farmer's rotation of crops. Cornellie planted soybeans on the 1991 pasture adding no fertilizer and cultivated for weed control. The pasture land grew a lush, weed-free crop of soybeans.

Cost of Pasturing Pigs

Added Costs	
Portable Fencing (lasts for 10 years)	$1400
Reduced Costs	
Medicated Feed	$480
Labor	$1000
Income	
88 pigs @ $95/ea.	$8360

Management Tips

a. As weather cools, provide a wind break, plenty of bedding, and double the ground feed for the pigs.

b. Do not cut back on vaccinations or deworming.

c. Full feed the young pigs.

d. Put the pasture on a different field each year.

Location of Project

6 miles south of Elbow Lake on Highway 54; 2 miles west on County #8; 1 mile south on gravel road. Farm is on the corner.

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Project Title:	**Evaluating Diatomaceous Earth as a Wormer for Sheep and Cattle**	*Time Span:*	April 92 to December 94
Principal Investigator: *Address*	David Deutschlander R.R. 4, Box 43 Pine City, MN 55063	*Tel:* *County:*	612-629-2744 Pine
		Enter-prise	Sheep, Dairy

Project Description

Controlling parasitic worms in a livestock operation is critical in maintaining a productive and healthy flock of sheep or herd of cows. Medicating the animals to control parasitic worms in many cases is time-consuming, labor-intensive, and expensive.

Diatomaceous earth (D.E.) , fossilized deposits of diatoms (tiny phytoplankton found in oceans and lakes), has been used for centuries to control insect pests and parasites. The silica shell of the diatoms kill insects and worms upon contact by dessicating and absorbing the waxy or oily cuticle layer of the bugs. D.E. is advantageous compared to synthetic insecticides or de-worming medication because it is natural, effective, non-toxic, and affordable.

Many producers are not aware of this resource so this project will:

1. Demonstrate and evaluate the use of D.E. as a wormer when fed to ewes on pasture, and when fed in a mineral mix.

2. Compare weight gains (feed efficiency) of confinement lambs with or without D.E. treatment.

3. Evaluate D.E. as a wormer for dairy youngstock on pasture when fed in a mineral mix.

4. Record observations of the fly control and external parasite control potential of D.E. in livestock production.

Project Results

Both lambs and heifers were given D.E. free choice. The lambs were observed to eat D.E. and go back for more.

Before this study began, the ewes tested *medium* level of (Haemonchus) barber-pole worms. D.E. was fed to the ewes at a rate of 50% D.E. and 50% mineral supplement. Twelve weeks after D.E. treatment, the ewes tested *medium low* Haemonchus although no other worming medication was used.

Lambs fed with D.E. appeared to have a faster weight gain, cleaner tails, and brighter wool. The overall body condition of the lambs seemed to improve.

D.E. fed free choice to 500 pound heifers on pasture showed no worms either mid- or late-season. The cattle consumed D.E. at a rate of 1 lb per week per heifer.

There appeared to be less problem with gnats on the faces and backs of the animals sprinkled with D.E.

D.E. may also have contributed to reducing the number of flies on the farm.

Cost Comparison of Diatomaceous Earth to Conventional Worming Medication

Conventional Medication*	\$1.50/head/year
Diatomaceous Earth	\$0.20/head/year

*administered 3 times/year - very labor intensive

Location of Project

North of Pine City on Hwy 61; 1 mile turn west on County Rd. 11; go 3-1/2 miles; after Nelson's Processing Plant take 1st road to right. We are first farm on right; all white buildings.

Crops.....

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HOLISTIC RESOURCE MANAGEMENT FOR CROPLANDS

Allan Savory
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This heading covers all plants grown and harvested as crops -- grains, fruits, vegetables, various fibers, timber, etc. -- and under it we are gathering information to guide you. We use the word "croplands" as opposed to "crop" to help draw attention to the fact that the layout and size of the fields is as vital to their sustainability as the crops grown in them.

We cannot provide the kind of detailed information many of you want, like which crops to plant and where, but we can develop principles that will help you make those decisions. A fundamental of Holistic Resource Management, remember, is that only whole situations can be managed and each whole is unique. Not only is it unique and not duplicated anywhere in the world, it's various aspects -- land, people, money -- are different every year. This means there can never be any "approved" or "standard practice" other than to manage through the holistic management process.

Over the past 30 years we've managed to establish a set of sound, and well-researched principles that ranchers have used, in combination with a thorough biological planning procedure, to ensure their success. Under the "Croplands" heading we are attempting to provide the same assistance to farmers. We're gaining experience as fast as we can and have thus far developed a handful of principles for sustainable cropping.

When I talk about "principles" I'm referring to points that apply universally. Most are not likely to change whether you are growing crops in a desert or a jungle, although some could change with the scale of brittleness. They lack the detail that farmers concern themselves with in day-to-day management. Those details have to be worked out by individual farmers or farmers in small communities, just as ranchers have to work out the day-to-day details of how their livestock run.

It is the principles that need scrutinizing today. All the detail in the world won't help if the underlying principles are unsound and they certainly appear to be in mainstream agriculture. In America today, we have available a tremendous amount of information on crops and a massive extension service to pass on the details to farmers. Yet, despite this, eroding soil, not the crops grown in it, is our greatest annual export.

That's a fairly strong indication that the principles underlying mainstream crop farming are unsound. Most of them were founded on the belief, propogated by agricultural economists, that large areas of monoculture crops were manageable. But

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Farmers must renew their confidence in their own abilities and particularly in their powers of observation, otherwise they cannot create the answers they need.

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I'm not aware of any scientist in the world who knows how to successfully manage a large expanse of any monoculture. In terms of the ecosystem, a monoculture creates utter chaos. As you'll see, the principles we've developed thus far reflect an underlying belief in the necessity for diversity and complexity in both the crops and their surroundings.

Once the underlying principles are on sound footing, you can work out the details with some confidence. In this case, the details are better left to the farmers themselves because they are the only experts when it comes to their quality of life, the land they live with every day, and the wealth they can generate from it for generations to come. Thus, it is not a job for the scientists or research stations, although they can be of assistance.

We're not the only ones saying this: A number of sustainable agricultural organizations are promoting on-farm research because it has proven to be so effective in developing the necessary detail.

Remember, that almost all the staple crops sustaining us today, as well as the livestock, were domesticated, bred and developed by farmers long before there was a single scientist. In fact, through our efforts, we scientists have *encouraged* the loss species and varieties that it took farmers thousands of years to develop.

Farmers must renew their confidence in their own abilities and particularly in their powers of observation, otherwise they cannot create the answers they need. The scientific method, good as it is, cannot create create anything. Only observant and creative people produce new knowledge. The research conducted according to the scientific method only allows us to check the validity of our observations.

Cropland Management Principles

1. Keep soil covered throughout the year. This is essential for healthy water and nutrient cycling as well as successional complexity. In addition, soils left bare over winter may contribute large quantities of nitrogen to underground water supplies. (Research plots in England showed that this phenomenon was not due to fertilization, as suspected, but was a direct consequence of the bare soil).

2. Endeavor to maintain great complexity in the community -- many species of plants, animals insects and microorganisms, both above and below ground, in the fields themselves and in the land surrounding or bordering them. Avoid monocultures of any species. (Move away from them to rotations of monocultures then intercropping, rotations of intercrops, alley cropping, and ultimately to polycultures).

Maintaining complexity refers not only to species diversity but also to genetic diversity. Remember the lack of genetic diversity that led to the Irish potato famine.

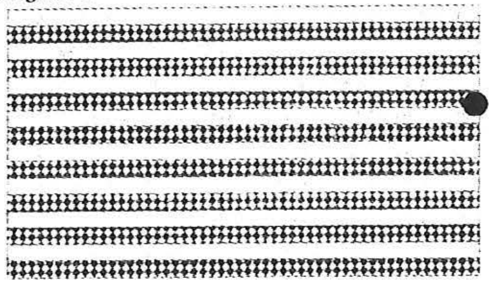
Try not to view plant and animal life as being engaged in a competition for survival. All life is involved in synergistic (or holistic) relationships which, unfortunately, are generally beyond our understanding. The pronghorn being eaten by a wolf or the plant being eaten by a caterpillar do appear to compete. And yes, all victims develop protective or evasive methods to defeat their "enemies." We need, however, to view these behaviors in relation the whole and the great cycle of birth, growth, death and decay. Without this process there would be no healthy life or soils.

When maximum production or yield of any particular crop is your goal, you give yourself an incentive to kill weeds and pests that may reduce production quotas. When you specify profit, rather than production quotas, you greatly decrease the incentive to kill weeds and pests. The dollars you spend to remove unwanted weeds and pests are often greater than the dollars you lose through decreased yields.

3. To maximize complexity, maximize "edge effect" when you lay out your fields. The greatest complexity is found at the points, or "edges," where different habitats meet. In Diagram A, for example, one very large field provides minimum "edge" -- two different crops provide two different habitats and the one water point provides a third. The greatest diversity of species of all types will be along the edge where the three habitats meet, followed by the edges where the two crops meet. Assume a certain species of bird required cover, feed and water in proximity. If one of the habitat types

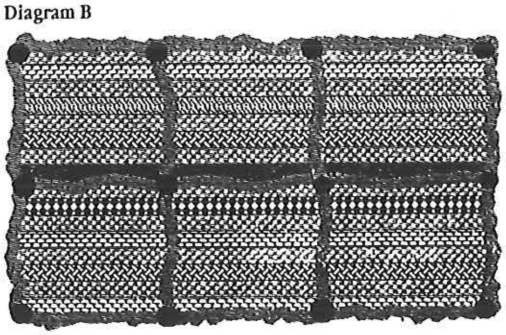
provided cover and the other feed, but no water there would be no birds of this species. Even with intercropping in this field there is little diversity.

Diagram A



Minimum edge effect: two different crops and one water point in one large field.

Diagram B



Edge effect maximized: many different crops, dispersed water points, and smaller fields divided by hedgerows and trees.

In Diagram B, hedgerows and trees have been used to divide the field into six smaller fields and water has been dispersed. What a difference! The trees and hedgerows add another dimension of complexity -- the proportion of edge is many times greater. Many creatures can obtain food, cover and water. Where an insect-eating bird was restricted to the cover at the edge of the field in Diagram A, it can now range over the entire crop area.

In designing your fields to maximize diversity, give thought to the needs of night creatures as well. You might add nesting boxes for birds but what about bats? The tonnage of insects eaten by bats at night is staggering. Unfortunately, many bat populations have been destroyed in order to maintain monocultures. You can encourage their return by providing cover.

4. Do not mow and tidy up around the edges of fields. What appears an untidy mess to you is cover and habitat for spiders and other insects that add to the complexity and thus the stability of the whole. Farmers are able to grow crops in complex polycultures in some of the most heavily insect-infested areas of the world without any insecticides. Some of these polycultures yield more than our monocultures.

5. Utilize grazing animals in your crop rotations. This is especially important in brittle environments where they play a critical role in cycling carbon. We may not, in fact, be able to keep soils alive in such environments without the help of grazing animals which speed decay by passing crop residues through their gut. In nonbrittle environments small organisms alone can perform this role.

6. Do not turn soil over, work it from the surface. Encourage aeration and porosity by planting crops that vary in type of root (fibrous or tap) and in root depth. Healthy forest and grassland soils are characterized by complex root systems, ample surface litter and considerable animal activity.

The principles given here are basically an attempt to imitate nature as closely as we can. The amount of productivity lost from our biological communities in the last century alone is staggering. Families, communities, towns and cities are all being sacrificed in order to overproduce ever-decreasing crop varieties. To assure our own survival we must restore the productivity and stability derived from the great complexity we once had.

Although we still have much to learn, these principles should give you a sense of direction. Remember that in managing holistically you will only be making consistently better decisions towards a clear, three-part goal. You will not be changing everything overnight and you should not take any step unless you first test it against your goal. That testing will ensure that you do not sacrifice the profit or quality of life needs that may override other considerations in any year.

Allan Savory is the founder of the Center for Holistic Resource Management. He was born in Zimbabwe and worked as a wildlife biologist until political turmoil there brought him to the United States. Over the past 30 years, he developed the principles for Holistic Resource Management which have provided tools for farmers, ranchers and others in land management to be environmentally sound, profitable and socially responsible. This article is reprinted from the HRM newsletter.

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CONTROLLING SOIL EROSION FOR LOW RESIDUE CROPS

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Traditional production practices in potato, sugar beet, dry bean, soybean, sunflower, silage corn, and many other row crops reduce or eliminate surface plant residue. With less than favorable crop residue cover, wind and water erosion can be a serious problem during the fall, winter, and spring months. It is known that soil erosion results in a major loss of the soil's productivity which will require more fertilizer and other inputs to maintain adequate production levels. Eroded soil usually ends up in water ways, lakes or ponds polluting these systems amplifying this destructive phenomena.

There are several methods that can be employed to reduce or eliminate soil erosion. The majority of these systems are relatively inexpensive to implement and can be accomplished with very few changes to an existing cropping system.

Interseeded Cover Crops

Practices that are being tried involve interseeding winter rye, other small grains, or some type of legume such as sweetclover ahead of the row cultivator during the last cultivation. A rotary spreader attached on the front of the tractor is the common way of spreading the seed. The cultivator incorporates the seed, and if there is moisture present, the seeds will germinate. The cover crop will then be left to add cover after the main crop is harvested. This practice is more practical with corn, row cropped silages, and sunflower. On-farm trials have shown that increasing the seeding rate or earlier planting dates in sunflower have improved establishment of sweetclover. Studies conducted at North Platte, Nebraska included seeding the legume at the same time as sunflower, using the insecticide box on the planter to distribute the legume seed in a band over the row. This proved successful in getting the legumes established and allowed for later between row cultivation. Cover crops such as a mixture of sweetclover and flax have been interseeded during the last cultivation in wide row dry beans. The beans were planted in 36 inch rows and narrow knives were used to cut the plants along the row leaving the cover crop standing in the center section between rows. Sweetclover, hairy vetch, and rye have had limited success interseeded in soybeans. Excess growth of the interseeded cover crop in soybean and dry bean can cause problems during harvest operations. For these two crops, this system is probably not the recommended method of erosion control. These different methods of cover crop establishment have not been found to work every time. Dry conditions, poor soil to seed contact, insect damage, and predominate crop competition have been found to be the major limiting factors to good cover crop establishment.

Sweetclover has been the cover crop of choice since it can fix nitrogen and the cost of seed is relatively low. In order to increase the chance of good cover crop germination and proper development, sweetclover should be planted before mid-July to develop adequate cover before the winter months. Usually 10-12 pounds of inoculated sweetclover seed per acre is adequate for good ground cover.

Cover crops such as winter rye and sweetclover will over-winter and may be a problem the next year if small grains are to be planted. An option to controlling these cover crops in the fall would be to spray them with a herbicide or undercut the growth with some type of sweep. Spraying with a herbicide such as Roundup would be the choice to consider if problem weeds such as quackgrass or some perennial weed were present. A tank mix of Banvel and 2,4-D will usually take care of late fall sweetclover establishments.

		Cost/acre
Seed		7.20 (Sweetclover$0.30/lb, 12 lbs/ac)
Application		$0.80
Termination		
	V Blade (1 pass)	$3.00
	Chisel Plow (2 pass)	$5.73
	Chemical*	$5.66

*includes 1 pt. Roundup + 1 pt. 2,4-D cost and energy consumption for manufacturing, operating, and repairing equipment.

Vegetative Barriers

Annual vegetative barriers are another unique way to control erosion. Barriers should be established at a right angle direction to the damaging, prevailing winds and on slopes of 6 percent or less. Suitable crops for annual barriers are: flax, corn, sorghum sudangrass, and sweetclover. The following table describes the specifications needed for proper erosion control using vegetative barriers.

Vegetative Barrier	Width of Barrier	Date of Seeding	Barrier I Interval
Flax	2-4 rows 6-14" spacing	prior to August 1	maximum 25 Feet
Sweetclover	2-4 rows 6-14" spacing	seed with prior crop	maximum 60 feet
Corn	2-4 rows 30-36" spacing	prior to July 10	maximum 60 feet
Sudangrass	2-4 rows 30-36" spacing	prior to July 15	maximum 60 feet

There are different methods of establishing vegetative barriers. One method is to mount a planter unit to the end of a row cultivator and plant the strips during the last cultivation (usually July). Usually the row crop planter markers are set a little wide on one side to allow for the strip crop to be planted in this extra area. Flax strips are a good choice for this type of establishment, however, grasshopper damage can be a problem. Corn and sorghum sudangrass are hard to establish on soil that has been treated with Sonalan or Treflan. Vegetative barriers can also help prevent dry bean windrows from blowing at harvest time and will trap snow during the winter months allowing for additional soil moisture accumulation for the following crop. Perennial grass vegetative barriers planted to tall wheatgrass have proven to be effective in controlling soil erosion and trapping snow during the winter. These barriers are usually effective when spaced 50 feet apart.

Alternating Strip Cropping

Alternating strips of crops are another unique way to control soil erosion with low residue crops. The width of each strip is usually determined by the width of the equipment. The idea is to plant every other strip to some high residue crop which allows the remaining strips to be planted to a low residue crop like dry beans. If the residue is left in fair condition on the high residue strips, soil erosion can be controlled. Another advantage of this type of arrangement is the possibility of reducing insect migration from one strip to the next thereby reducing insect damage. Certain crop combinations have resulted in a yield advantage when planted in strips. Additional sunlight, moisture, and nutrients that might be available on the edge rows have resulted in increased yields over a monocropped field. The best combination is to plant a grass/broadleaf and short season/long season system which will minimize the effect of common pests, growth habits and plant architecture. Good combinations for the Northern Great Plains would be small grains or corn in combination with dry beans, soybeans, sugarbeets, potatoes, or sunflower.

David Klinkebiel received his B.S. in agronomy from Colorado State University and his M.S. and Ph.D. in agronomy from the University of Nebraska. Dr. Klinkebiel's research interests include water utilization and water quality of production systems. He also works on sustainable cropping systems that deal with biological pest control and with alternative crop introduction, research and utilization.

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

Project Description

Legumes can be an excellent nitrogen source for cereal crops in western Minnesota. Two 2-yr studies examine the establishment of legumes followed by corn. Direct spring seeded "Nitro" alfalfa was evaluated for its nitrogen contribution to the next year's corn crop. In the other study, wheat underseeded with legumes, or wheat followed by fall-seeded legumes, was evaluated for its effect on the next season's corn crop. In both the alfalfa and wheat/legume treatments, the following corn crop was sidedressed with varying rates of N to evaluate nitrogen contributions from the legumes.

Research from other areas have shown that a spring seeded annual alfalfa provides up to 100 lbs of N if you take cuttings through the summer and incorporate the roots and forage in the fall. Also, a fall seeded legume such as hairy vetch will provide 40-70 lbs of N, recovering about 5 lbs of N per inch of growth if the forage is incorporated. Most of this research has been done in more centrally located states where growing seasons are longer and ample rainfall more predictable than in west-central Minnesota.

It is important to identify techniques to manage legumes for providing nitrogen to grain crops in this area. Management strategies include:

a. what is the best time to plant legumes;
b. which legume species are most appropriate for wheat-corn cropping system; and
c. what is the best way to incorporate the legumes.

Johnson's goal is to use legumes to reduce his inputs as much as possible while maintaining satisfactory corn yields.

Rainfall Data

1990	April - September	12.75"
1991	April - August	20.95"
1992	April - August	11.00"

Project Results

Legume	Seeding Rate (lb/A)	Cost/Lb
Nitro Alfalfa	13	$2.65
Hy-N Alfalfa	10	$1.30
Red Clover	10	$0.80
Hairy Vetch	20	$0.90

The legume treatment plots were established in 1990 with the corn grown the next year. Treatments were repeated in 1991/92.

Corn Yields after Wheat and/or Legume

Crop grown before corn in 1990 and in 1991	Amount N applied (lbs/A)[a]	1991 Corn Yield (bu/A)	1992 Corn Yield (bu/A)
NITRO alfalfa[b]	0	126.3	111
	40	135.7	109.6
	80	133.9	102
Wheat	0	125.7	
	40	127.3	
	80	144.4	
HRS wheat only	40	106.7	100.6
	80	113.5	93
Wheat underseeded with Hy-N alfalfa	0		103
	40	101.0	99
	80	114.2	93
Wheat followed by fall-seeded hairy vetch	40	101.4	
	80	110.7	
Wheat underseeded with red clover	0	Winter-killed	107
	40		95
	80		92.5

[a]Nitrogen side-dressed to corn crop; [b]NITRO alfalfa seeded at 13 lbs/A, and with 3 cuttings yielded 1.92 ton/A. in 1991

Soil Test Results
(Taken right before sidedressing corn)

Treatment Plot	1991	1992
	----lbs N/2 ft.----	
Nitro alfalfa	100	139
Wheat	112	
Alfalfa Hy-N underseeded	96	73
Hairy Vetch	52	145
Wheat only	96	98
Red Clover		389

Highlights from the Project

Legumes incorporated provided enough nitrogen to produce the corn crop. Higher rates of nitrogen used to sidedress corn crop resulted in lower quality (ligher and wetter) corn. Based on results from 1991 and 1992, Johnson believes that any nitrogen fertilizer applied over 40 lb/acre is a waste.

Results of Corn Harvested Oct. 5, 1992

N rate	Harvested Weight lb/area*	Test Weight lbs/bu	Moisture %	Dry Weight lb/area
0	1800	55	16	1775
40	1830	53	18	1753
80	1810	50	22	1633

*Harvest area = 670 ft x 20 ft (8 rows)

Johnson estimates that with proper management, this legume/crop system can maintain corn yields while reducing costs by about $30/acre.

Income/Savings Benefit (per acre) from using Forage Legumes

	NITRO Alfalfa	Hairy Vetch & Red Clover
Year 1		
Income from forage	125.00	25.00
Added seed costs	34.45	10.50
Net Increase	*90.55*	*14.50*
Year 2		
Reduced N	15.00	12.00
Reduced herbicides	10.00	
Net Increase	*25.00*	*12.00*

* The most valuable information drawn thus far is how the forages can be managed within the cropping system.

* The non-dormant alfalfa was easier to establish than anticipated. Weed control was not a problem at seeding, yields have been good even with low rainfall (only 12" during 1990 growing season). There was also very low weed pressure in the corn following the annual alfalfa.

* Hairy vetch is a challenge to manage even when good stands survive winter. In the spring, the corn must be planted before the vetch is over 6" tall or it interferes with planting equipment. Then when the vetch grows enough to supply some nitrogen to the corn, it is difficult to kill and incorporate to standing corn.

* Underseeded red clover and non-dormant alfalfa grew surprisingly well in the fall after wheat harvest. They reached 10-12" by mid-October and were moderately frost tolerant. Seed costs were reasonable, and the forage can be harvested with conventional equipment.

* Legumes should be allowed to grow to produce enough roots and forages to incorporate. With the right management, herbicides are unnecessary in this system.

Other Observation

One reason western Minnesota farmers are reluctant to grow forages through the fall and winter is fear that the forage crop will deplete soil moisture. Johnson has observed that 4-5" of rain is enough for some fall growth of underseeded legumes. Producers believe that the common practice of leaving wheat stubble on the field saves more soil moisture than planting a forage. However, Johnson's experience showed that allowing forages to grow (followed by late fall chisel plowing) does not deplete soil moisture any more than volunteer wheat or multiple fall tillage operations.

Another assumption is that weed pressure will be heavy in this system because growing legumes after wheat harvest does not allow for early fall tillage. However, Johnson observed no problems weeds after wheat harvest in areas underseeded with legumes.

On the plus side, there are several important biological and economic benefits to this cover crop system. It requires less fall tillage than conventional practices reducing potential wind erosion. The legumes compete well with weeds and reduce need for herbicides in the following corn crop. And they also contribute to soil nitrogen so that there is less need for nitrogen fertilizer.

Location of Project

1 mile north and 1 mile west of Herman.

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Project Title:	**Energy Conserving Strip Cropping Systems**	*Time Span:*	March 91 to February 94
Principal Investigator: *Address*	Gyles W. Randall University of Minnesota Southern Experiment Station Waseca, MN 56093	*Tel:* *County:*	507-835-3620 Waseca
		Enter-prise	Row crops with hogs

Project Description

Studies show that corn-soybean strip cropping systems, in which the crops are alternated in narrow rows, improve corn yields beyond monocropping systems due to the "border effect." Corn plants on border rows receive more sunlight for growth than those within the border. However, soybean yields are reduced because the plants are shaded.

Adding wheat to this strip cropping system would reduce shading of soybeans, without sacrificing wheat yields. On east-west rows, wheat planted north of corn and south of soybeans would allow adequate sunlight for the soybeans. The wheat, a cool-season crop, would not be shaded because it will head out before the corn gets tall enough to shade it. An additional leguminous component, either NITRO alfalfa or vetch, interseeded with the wheat would provide nitrogen to the strip crop system.

This project will compare yields and economics of the following cropping systems:

a) continuous corn
b) conventional corn/soybean rotation
c) wheat, wheat+NITRO alfalfa, wheat+vetch
d) corn-soybean-wheat (with and without legume interseed) strip

Continuous corn and the corn/soybean rotation will be planted on ridges. Wheat and legumes will be planted with minimum tillage drill to protect the ridges. Nitrogen rates will be varied to evaluate contribution of N-fixing legumes.

This system offers numerous environmental benefits. It should break pest (weed, insect, disease) cycles; conserve fuel from ridge system (requires fewer equipment passes through a field); and decrease nitrogen fertilizer needs (from legume component).

Highlights from 1992

1. Surface residue coverage was excellent before planting with all three previous crops and after planting with corn and wheat. Thus, erosion potential with this 3-crop system would be minimal.

2. Corn yields in the 3-crop alternate strip system were increased an average of 8% compared to the "whole-field" yields. Soybean and wheat yields in these north-south strips were reduced 8%. Soybean yields in alternate strips with corn were reduced 14%.

3. Border effects showed the outside rows of corn to yield 22% more than the center rows in the 6-row strips. Soybeans in the row bordering corn on the east yielded 29% less than the center rows while the west row bordering wheat yielded only 6% less.

4. Although interseeding of Nitro alfalfa and hairy vetch with wheat contributed some N to the system, corn yields following these two crops were reduced significantly because of competition to the corn. Both crops over-wintered very well, removed extra soil water from the surface 4", retarded early growth of corn, and were impossible to kill solely by ridge scalping and cultivation. Herbicide use will be necessary to kill these crops prior to planting corn.

5. Moisture at harvest was 1 to 2 points lower for corn in the alternate strips and was less than 1 point higher for both soybean and wheat compared to the "whole-field" average.

6. Nitrogen uptake and management efficiency, weed seed buildup, soybean cyst nematode activity, and economic return are being evaluated for these systems.

Surface Residue Coverage

Crops in 1991	4/6 Before Planting	5/20 After Planting
	--------%--------	
Corn	70	47
Soybean	40	21
Wheat	84	42
Wheat + Alf	92	65
Wheat + Vetch	86	53

Comparison of Strip and Whole-field Yields

Crop[1]	6-row Strip	Whole Field[2]
Contin. Corn	—	134
Corn-S	165	156
Corn-S-W	168	156
Corn-S-W+A	144	131
Corn-S-W+V	126	118
Soybean-C	32.9	38.2
Soybean-W-C	33.5	36.4
Wheat-C-Sb	50.2	54.4

[1]Corn received 120 lb N/A; wheat received 50 lb N/A.
[2]Assuming that the center 5' of each strip represented the whole-field.

Border Effects on Crop Yields

Crop[1]	Rows/Position 1	2	3&4	5	6
			------------bu/A------------		
Corn	195	160	156	158	187
Soybean	25.7	32.5	36.4	35.4	34.3

	East 1/3	Center 1/3	West 1/3
Wheat	52.3	54.4	50.2

[1]All in 3-crop alternate strip system.

Highlights from 1991

1. The alternate corn-soybean strip rotation showed 14% to 22% higher corn yields (depending on harvesting method) and 8% lower soybean yields compared to a whole field of each crop.

2. The alternate corn-soybean-wheat rotation did not reduce yield for any of the crops compared to a "whole field" monocrop. Corn yield increased from 15 to 17% depending on harvest method. Wheat grain increased by 2%, and straw yields increased by 11%. Soybean yields were not affected by strip crop system.

3. Economic returns need to be evaluated for this system.

Average Strip Cropping Grain Yields

Crop	Yield	Relative yield*
	---bu/A---	
Wheat	37.7	for all three
Wheat + Alfalfa	36.3	wheat systems:
Wheat + Vetch	35.8	102%
Corn	170.3	117%
Soybean	35.4	100%

*Compared to single crop average assuming center two rows (out of 6-rows) represents monocrop average

Location of Project

Two miles east of Freeborn on Freeborn County 29, or 5 miles west of intersection of MN Hwy 13 and Freeborn Co. 29.

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Project Title:	**Annual Medics: Cover Crops and Nitrogen Source**	*Time Span:*	March 92 to March 94
Principal Investigator:	Dr. Craig C. Sheaffer	*Tel:*	612-625-7224
Address	Dept. of Agronomy and Plant Genetics 411 Borlaug Hall University of Minnesota, St. Paul, MN 55108	*Counties:*	Dodge, Becker Wabasha, Itasca, Stevens, Ottertail
Cooperators	Maurice Weller, farmer, Morris, MN Dan French, farmer, Mantorville,MN John Meyer, farmer, Potsdam, MN	*Enter-prise*	Diverse crop and livestock

Project Description

Currently, most small grain farmers in Minnesota do not use cover crops. This situation can create soil erosion and nutrient leaching. Legume cover crops can provide soil cover, recycle nutrients, and provide additional N for subsequent crop.

"Innovator/early adapter" farmers from various parts of the state are collaborating in the study. Uniform fields have been identified and small grains planted. After small grain harvest, plots were established in a randomized block design with three replicates. Three medics selected based on experiment station trials as well as the three more common cover crops were seeded. Control plots have no cover crop seeded. Corn will be planted into the entire field the following spring. To determine the N fertilizer credits of the annual medics, control plots with three N rates are included for corn production.

The goals of the project are to evaluate:

1. fall forage production and N contribution of annual medics planted in mid-summer following small grain harvest;
2. late fall and winter residue produced for soil cover by annual medics;
3. the effects of annual medics on soil N levels, weed control, and yield of a subsequent grain crop.

Project Results

Sheaffer evaluated annual medics, alfalfa, and rye grain at five farm locations in 1992. Legumes and rye grain were broadcast seeded or drilled after oat harvest at each location. Below normal temperatures during the 1992 growing season delayed oat harvest and cover crop planting at all locations. Late planting resulted in negligible growth of all cover crops at Grand Rapids and Detroit Lakes and no data was collected from these locations. Yields of all cover crops were determined at Mantorville, Morris, and Potsdam in October by harvesting a 3 by 20 foot area within each plot. Forage subsamples were collected for N determination.

At Mantorville, Morris, and Potsdam, the second phase of this research will be conducted in 1993. We will determine the fertilizer N equivalency of the cover crops by planting corn over all plots and by planting corn on previously fallowed land treated with several rates of applied N.

Observations

Planting and harvest dates for annual medics, alfalfa and rye grain at five locations in 1992

Location	Planting Date	Harvest Date	Planting Method
Mantorville	28 July	5 October	Broadcast
Morris	31 July	21 October	No-till drill
Potsdam	5 August	5 October	Broadcast
Detroit Lakes	12 August	----*	No-till drill
Blackberry	1 August	----*	Broadcast

*Plots were not harvested because of insufficient growth

Seeding rates for forage legume and rye grain cover crops.

Cover Crops	Seeding rate (lb/acre)
'Kelson' snail medic	30
'Sava' snail medic	30
'Santiago' burr medic	12
'Dacold' winter rye	60
'Common' hairy vetch	30
'Nitro' alfalfa	20

The success of any fall cover crop system in the north central region is strongly influenced by the weather conditions. In 1992, cover crop growth was adversely affected by late planting and below-normal fall temperatures. Yields of forage dry matter and N by all cover crops were less than expected.

Fall forage dry matter yields and nitrogen (N) yield and concentration for forage legumes and rye grain planted after small grain harvest in 1992 at Mantorville, MN.*

Crop	Stand	Weed-free Forage Yield	Total Forage Yield	Forage N Concentration	Forage N Yield
	%	-----Ton/acre-----		%	lb/acre
Kelson snail medic	93	1.2	1.3	2.8	73
Sava snail medic	92	1.5	1.6	2.9	93
Santiago burr medic	77	0.8	1.1	2.5	55
Dacold winter rye	57	0.3	0.5	2.3	23
Common hairy vetch	67	0.9	1.4	2.5	70
Nitro alfalfa	78	0.8	1.0	2.9	58
Caliph barrel medic	95	1.6	1.7	2.9	99
Fallow	–	0.0	1.0	2.1	42
LSD (0.05)	19	0.3	0.4	0.4	23

*Harvest date, 5 October 1992

Fall forage dry matter yields and nitrogen (N) yield and concentration for forage legumes and rye grain planted after small grain harvest in 1992 at Morris, MN.*

Crop	Stand	Total Forage Yield	Forage N Concentration	Forage N Yield
	%	Ton/acre	%	lb/acre
Kelson snail medic	91	0.4	3.8	32
Sava snail medic	94	1.1	3.6	78
Santiago burr medic	83	0.3	3.1	16
Dacold winter rye	80	0.8	3.2	51
Common hairy vetch	70	0.6	3.7	45
Nitro alfalfa	83	0.6	3.8	44
LSD (0.05)	9	0.2	0.4	18

*Harvest date, 21 October 1992

Fall forage and root dry matter yields, and nitrogen (N) yield and concentration for forage legumes and rye grain planted after small grain harvest in 1992 at Potsdam, MN. *

Crop	Stand	Weed-free forage yield	Total Forage Yield	Root & Stubble Yield	N Concentration		N yield		
					Forage	Root	Forage	Root	Total
	%	----------Ton/acre----------			------%------		------lb/acre------		
Kelson snail medic	90	0.8	0.9	0.2	3.0	1.5	53	5	58
Sava snail medic	95	1.1	1.2	0.1	3.0	1.5	69	2	71
Santiago snail medic	88	0.7	0.8	0.1	3.2	2.1	48	5	53
Dacold winter rye									
Common hairy vetch	28	0.1	0.4	0.2	2.6	2.4	22	9	31
Nitro alfalfa	83	0.5	0.7	0.1	2.8	2.6	36	6	42
Caliph barrel medic	88	0.8	0.9	0.1	3.1	1.8	54	5	59
Fallow	---	0.0	0.6	0.1	1.8	0.8	20	2	22
LSD (0.05)	13	0.1	0.2	---	0.4	---	11	---	11

*Harvest date, 5 October 1992

Sava snail medic was consistently among the cover crops with the highest fall forage and N yield. At two of the three locations, winter rye had the lowest yields. Low yields of winter rye and hairy vetch at Potsdam were associated with poor stands.

At Mantorville and Potsdam, yields of volunteer oats and weeds in the fallow (non-planted) plots were sometimes equal to those of some established legume or rye cover crop treatments, but were always less than those of the highest yielding cover crops. Nitrogen in legume cover crops is expected to originate primarily from fixation of atmospheric N; whereas, N in winter rye, volunteer oats and weeds is extracted from the soil. The N contributions of these cover crops will be confirmed by planting grain crops in 1993.

Sheaffer concluded from this first year of research that Sava annual medic has good potential for use as a fall cover crop as an alternative to hairy vetch and winter rye which are commonly grown cover crops.

Management Tips

1. Harvest small grains as early as possible.
2. Remove or disperse small grain straw. Piles or windrows of straw can prevent good soil-seed contact and hinder seedling development.
3. Cover crops can be established following small grain harvest using no-till drills or by broadcast seeding and packing following shallow tillage. Tillage can be accomplished using a disk or drag but should expose soil and destroy any existing weeds. If seeded following shallow tillage, seed should be incorporated from one-quarter to one-half inch. Legume seed should be inoculated with the proper bacteria to insure effective biological nitrogen fixation.

Location of Project

Maurice Weller Farm - Morris, MN, East of Hwy 59, 1 mile on Hwy 329

Dan French Farm - From Rochester, MN, West on Hwy 14 to Hwy 57, north on Hwy 57, 2 miles

John Meyer Farm - From Rochester, MN, North on Hwy 52 at Oronoco Exit, East on Hwy 12 to Potsdam, North 1 mile at intersection

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Project Title:	**Chemical Free Double-Cropping**	*Time Span:*	April 90 to December 92
Principal Investigator: *Address*	Jeff Mueller Route 1, Box 86 Swanville, MN 56382-9801	*Tel:* *County:*	612-547-2288 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, including:

1) reduced row crop acreages and the number of trips over a field/crop;

2) reduced herbicide usage through increased rotation and solid seeding;

3) reduced need for purchased nitrogen because of more efficient use of manure;

4) reduced soil erosion and ground/surface water pollution by herbicides and chemical fertilizers.

Average Forage Quality over 3 year period (1990-92)

	CP	TDN	ADF	RFV
	--------%--------			
Oats/Peas	16	52	38	100
Triticale/Peas	18	55	35	110
Milage*	14	50	42	100
Alfalfa	19	59	32	130
Fall Triticale	18	55	40	115
Corn Silage	8	65	30	---

*Milage = Forage soybean mixed with grain sorghum
CP=Crude Protein; ADF=insoluble protein; TDN-total digestible nutrients; RFV-relative feed value

Three Year Results (1990-1992)

Double Crop Treatment	Planting Date	Harvest Date	D.M. Yield[1] Tons/Acre
----------1990----------			
Triticale / Field Peas	5/1/90	6/30/90	1.45
Forage Soybeans and Popcorn	7/10/90	9/12/90	1.42
----------1991----------			
A. Fall Triticale	Fall '90	6/7/91	2.9
Milage[2]	6/15/91	9/5/91	2.5
B. Alfalfa	3 yr stand	6/7/91	2.1
Corn Silage	6/15/91	10/15/91	4.5[3]
C. Alfalfa	3 yr stand	6/7/91	2.1
Milage	6/15/91	9/5/91	2.5
D. Fall Triticale	Fall '90	6/7/91	2.9
Corn Silage	6/15/91	10/15/91	4.5[3]
----------1992----------			
A. Spring Triticale/Field peas	5/1/92	7/7/92	3.5
Alfalfa (undersd) 15 ac	5/1/92	9/1/92	1.0
B. Alfalfa (2nd yr) 10 acres	5/91	6/1/92 7/15/92 Plow down in 9/92	1.5 1.4
Corn silage-7 ac	5/1/92	10/1/92	12.9 (wet)
Corn grain-8 ac	5/1/92	11/20	100 bu/ac

[1]Dry matter yield
[2]Milage = forage soybean mixed with grain sorghum
[3]Corn silage yield before drying: 14 tons/acre

Highlights from 1990

1. Thick ground cover of both forage crops provided complete weed control. No new weed seed was produced in 1990.

2. Triticale/peas forage quality is high whereas popcorn/beans quality is marginal for dairy cow rations.

3. Seed costs are high, but are justified by eliminating pesticide costs.

4. 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.

5. Triticale/peas are difficult to harvest due to lush growth and moist condition clogging cutter bar.

Highlights from 1991

Fertilizer Regime

6,000 gal/acre of liquid dairy manure was applied to both the alfalfa and triticale ground after the June 7 harvest and before the June 15 planting.

Calcitic powdered lime was added to the manure pit while agitated (before pumping). At 6,000 gallons of liquid, about one ton of lime was spread per acre.

Tillage After Initial Harvest

Treatment A
    mulch finisher/plant with press drill
Treatment B & C
    moldboard plow/conventional planting
Treatment D
    no tillage/plant in stubble with conventional planter

Observations for 1991

1. Yields of dry matter forage were much higher in 1991 than in 1990.

2. Fall-seeded triticale successfully overwintered from Fall '90 to Spring '91 due to adequate snow cover and earlier seeding date. (Triticale from '89-'90 winter-killed.)

3. Forage quality was adequate for high-producing dairy cows, especially when mixed, i.e. triticale and alfalfa alternated round for round while chopping for silage.

4. Alfalfa to corn, and triticale to corn (Treatments B & D) plots were easily maintained with cultivation and herbicide at 1/2 the recommended rate (Bicep @ 1 pint/acre with Actio-301 as an extender). Check strips within the corn plots with no chemical weed control showed no significant yield loss in Treatment B but in Treatment D almost a total loss. Timeliness of row cultivation may have been a factor.

5. Weed control in all treatments has been good in both 1990 & 1991.

6. Forage quality and yields improved in 1991 partly due to different forages in the treatments and partly to more favorable weather and timeliness of liquid manure applications.

Highlights from 1992

The triticale/field pea mixture had higher yields this year than previous years probably because of the wet spring. Although weeds were not a problem in previous seasons, the cool, wet weather this year made it difficult to mechanically cultivate weeds in corn crop. Herbicide was spot sprayed on 4 acres of corn.

After three years of experimenting with this system, Mueller is happy with some of the forage combinations and plans to continue using them. He will continue to use triticale/peas as a nurse crop in alfalfa, harvesting the trical peas in June and harvesting the first crop of hay in August. He will use milage as an emergency crop only when labor in mid-June is scarce. Mueller plans to continue to reduce chemicals on corn using rotary hoe and crop rotation. Fall-planted triticale doubling with corn works well, as does corn silage following first crop alfalfa. However, timeliness and labor may be limiting in the latter cropping system.

Environmental Benefits

1. No insecticides are needed.
2. Continuous ground cover protects the soil.
3. Excessive nitrogen is removed from the soil by double cropping system.
4. Legumes in the mix complement the grasses in maintaining soil fertility.
5. No-till seeding techniques can be used.

Partial Cost Analysis (per acre per year)

	Triticale/Milage Double Crop	Conventional Corn
Seed	$50	$17-$25
Fuel, equipment	$55	$45
Pesticide	$5	$20
Fertilizer	-0-	$30

Management Tips

1. Double cropping of forages is adaptable but involves very timely harvest and reseeding dates to assure high quality forage and maximum use of growing season.

2. Triticale/peas mixture is a good companion crop for alfalfa or clover.

3. Trical Peas and fall Trical in double cropping systems are a good option to use as backup crops when alfalfa winter kills or fails.

4. Feed quality of the first crop is higher than the second crop. Trical (spring)/peas mixture is higher quality than oats/peas. This forage must be seeded as early in the spring as possible.

Timeline Guide for Managing Forage Double Croppping System

Forage Type	Optimum Seeding Dates	Optimum Harvest Dates
Fall forage triticale	by Sept. 20	by June 20* while still in boot stage for best quality
Spring forage triticale or oats and Canadian Field Peas	before May 5	by June 25* while grain is in boot stage for best quality
Milage (forage soybeans with grain sorghum)	before July 5	by Sept. 15 at about 36" height for best quality

*Small grain maturity (pre-boot stage) must be monitored very closely to harvest maximum quality forage. There is probably only a 3-5 day harvest window.

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

Project Description

Double cropping potentially reduces soil erosion and weed pressure by providing a more complete soil cover than a single crop. This project will demonstrate the feasibility of interplanting soybeans with oats. 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.

In 1990 and 1991 oats were planted with a drill and interseeded with soybeans in 30" rows. In 1992 barley was used as the small grain. The small grain was planted first, and the soybeans planted 10 and 20 days later.

Project Results

The first two years of this project have met with unfavorable weather conditions. Excessive rains both in 1990 and 1991 reduced oat crop yields. Grass weeds overcame oats. While combining oats, soybean tops were inadvertently chopped off which reduced soybean yields as well.

Part of the problem is that the timing of oat harvesting overlaps too much with soybean growth. Weber decided to use a barley in place of oats for the 1992 growing season. Barley can be harvested earlier than oats, and the heads of barley grows higher than oats which should allow for the barley harvest without damage to the soybean crop.

Because of dry conditions at planting in 1992 there was only a 20% germination rate for the barley. With this poor germination it was decided that the project be cancelled for the third year and to kill the barley and rescue the soybean crop. Weber found out that barley is very hard to kill with Poast and Pursuit herbicides, and two cultivations were also necessary. No cost analysis and comparison of cropping systems were made in 1992.

Highlights from 1991

Excessive rains both in 1990 and 1991 reduced oat crop yields. In 1991 grass weeds overcame oats. While combining oats, soybean tops were inadvertently chopped off which reduced soybean yields as well.

Cost Analysis and Comparison of Cropping Systems -1991

	Oat/Bean*	Oat only	Bean only
Yield (bu/A)	oat - 25 bean - 6	32	36
Gross Income	$55.50	$35.84	$180.00
Oat seed	$6.50	$6.50	
Bean seed	$13.50		$13.50
Combine	$40.25	$40.25	$40.25
Planting costs	$15.00		
Herbicide			$20.80
Production Costs	$74.25	$46.75	$74.55
Net Income	- $18.75	- $10.91	+$105.45

*"bean" = soybean

Although yields were disappointing from double crop system, soil erosion was reduced. The 33" of rain received between March and October would have been much more erosive without the oat cover.

Highlights from 1990

Poor weather made it difficult to evaluate the potential of this system in 1990. Excessive rains and winds damaged the oat crop. Lodging problems made it difficult to harvest oats and beans.

Combining costs of harvesting in a double cropping system are somewhat higher than in a single 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.

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Soils.....

Compost turners

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SOIL QUALITY, SOIL STRUCTURE

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I have sometimes heard older farmers remark that soils no longer have the same quality that they had when those farmers were children. Speaking for myself, observations I have made on many farm visits in the Midwest, indicate to me that we are presently harvesting the consequences of an epidemic of poor soil quality in the forms of soil compaction, erosion, and root disease.

Ultimately, all these inter-related problems can be traced back to the fact that we neither understand soil quality nor how important it is to maintain it. Admittedly, as farmers we have become more and more isolated from our soils. We sit in large tractors and find often little time or have little inclination to look at our soil, to smell it, and to sense its quality and livingness. Also, it has become common in our time to think of our soils as simply being sponges for holding nutrients and water for our plants. In reality, soil is actually more that that. Soil is a partly living and mineral substance that responds strongly to how we treat it.

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The soil can teach us a great deal if we observe it.

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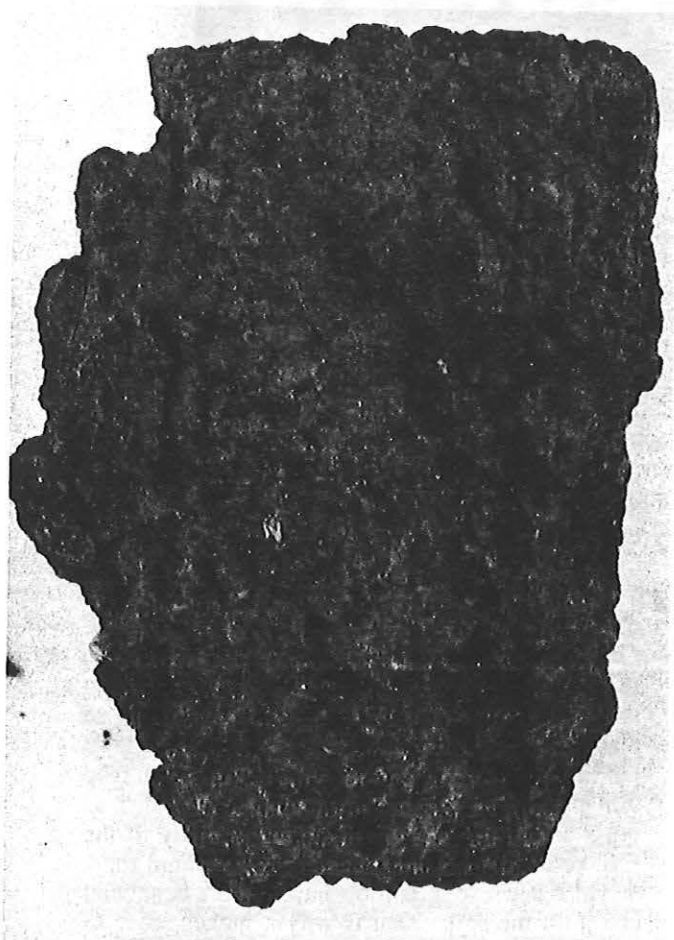
Furthermore, many farmers have lost their sense for what healthy soil is and their knowledge of how to develop it. Hardly anyone talks about it; we treat the problems caused by poor soil quality with fragmented technical measures such as increasing fertilizer applications or using more pesticides or no-till. The consequence of all this is that soil is becoming deader, more compact, prone to erosion and root diseases, and increasingly risky for crop production.

Like all living things, soil has a form. Learning to read the form can give a farmer a direct relationship to the quality of the soil that can help that farmer make management decisions. Let me show you an example. In photograph 1 you see a heavy clay prairie soil from central Iowa that has been in a continuous corn-beans rotation for many years.

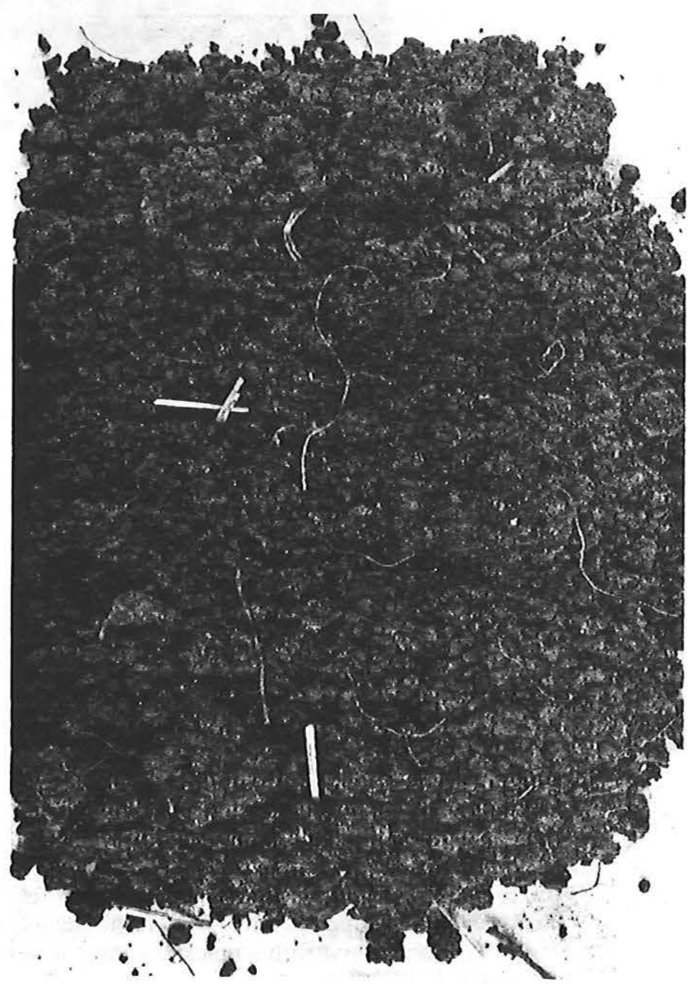
In photograph 2 you see a sample of the some soil taken about eight feet away from the first; it has been under brome grass.

Note that the soil in the first photograph is highly compacted. The bulk of the material is melded together to form an amorphous block that breaks into pieces that have sharp, mineral-like angles. This soil is characterized by a lack of large pores that can conduct air into the depths and into which roots can grow. The soil that has been in brome-grass is strongly aggregated into stable crumbs that resist compacting into an amorphous mass. There are more large pores in the soil because of the packing geometry of the crumbs and because of the increased numbers of small animals that make burrows. Such pores allow water and air to get into the soil and they allow roots to better explore the soil to fin d the nutrients and water they need.

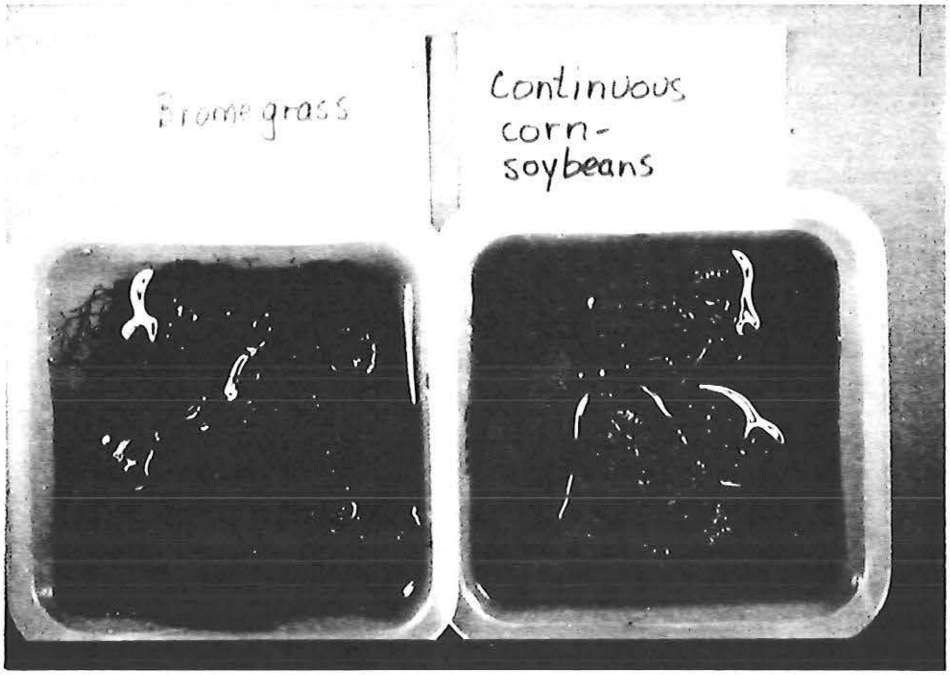
PHOTOGRAPH 1



PHOTOGRAPH 2



PHOTOGRAPH 3



Photograph 3 shows what happens when water hits these two soils. Small quantities of the air-dried soils have been placed in a tray and water has been poured in. Under corn-beans cropping, the soil dissolved and released its clay into the solution. Under brome-grass, the stable crumbs resist breakdown and hold their clay constituents. You can imagine what kind of impact this kind of difference can make during a rain storm in terms of soil erosion.

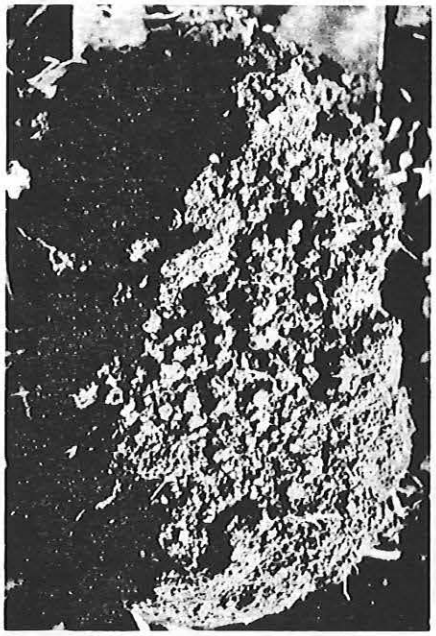
To a certain extent, it is possible to judge a soil simply by looking at it. Is it well structured with a lot of spherical crumbs or is it compacted, amorphous, and massive? Does it have a lot of crumbs in the size range between 1/32 and 1/3 inch in size? These are the crumb sizes that build up with good crop rotations that include forages, green manures, and animal manure applications. As these crumbs build up, you can be assured that the "fat of the land" is increasing. It is just such crumbs that are most active in releasing nitrogen to crops and that have the most active microbial activity. The powdery material and clods are not so active. Hence, inspection of the crumb status of your soil should give you a quick assessment of its potential fertility.

However, as you make your observations, be careful, as it is easy to get fooled by tillage which can fluff up and crumble soil and make a soil that is in poor shape look crumbly. But the crumb structure of such a soil is not stable and the soil slumps easily back to its massive condition. Actually, the way a soil acts under tillage can be instructive. Soils that are in good shape maintain a large portion of their constituents in the crumb size range mentioned. Soils that have lost a lot of their fertility produce powder or clods more easily. Of course, tillage can have a beneficial effect on soil structure when it is done at the right moisture content in the right way, but it can have negative effects when done when soils are too moist or dry.

As we have mentioned, different crops have different effects on soil structure and fertility. Certainly, crumbs appear under annual grain crops such as wheat, corn, and soybeans as a response to the roots of those crops. However, after those plants are harvested for grain the crumb strength of the soil decreases below what it was before the crop was grown. This is not the case for forages such as grass and alfalfa. They build the stability of the soil, probably because they have a lot more roots and also because their roots have a more beneficial effect on the soil. That is why it makes sense to use crop rotations that include a mixture of grain crops and soil-building forages or green manures.

An example of the effect of grain cropping is shown in Photographs 4 and 5 which show top-soil profiles from test plots on a silt loam in southern Wisconsin, taken in May. Photograph 4 shows soil from a plot that was in oats underseeded with sweetclover the previous year; the sweetclover was disked under as a green manure crop in the spring and the soil is now ready for planting corn.

Photograph 5 shows a soil profile from a side-by-side plot that was in oats and sweetclover two years before and then was followed by corn. Note the difference in crumb structure and massivity.



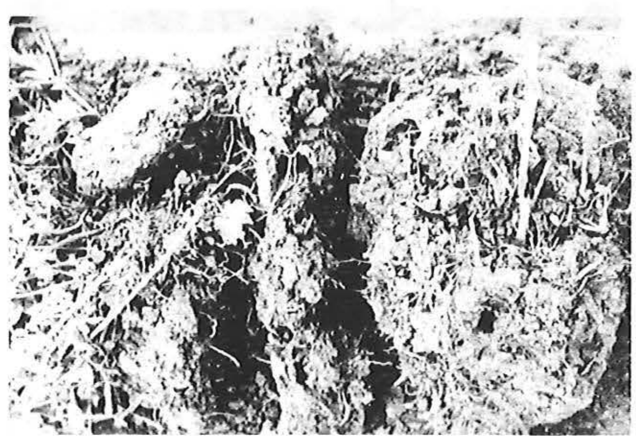
PHOTOGRAPH 4

Corn actively destabilizes soil aggregates by releasing acidic substances from its roots. It is instructive to witness soil structure in soil that has been continuously cropped with corn. In our area, fall-plowed ground that has been in monoculture corn often produces monolithic clods that can be a foot or more in diameter.

The effects of crops on soils are not only due to the qualitative and quantitative effects of their roots. Earthworms are stimulated by certain crops, especially by leguminous forages, and their activity greatly adds to the stability and structure of the soil. It is not uncommon to have earthworm numbers double under a crop of hairy vetch or sweetclover and the highest numbers of worms are generally found under pasture. Worms like proteinaceous food that legumes and manure can provide; they are not as partial to cereal straw.

PHOTOGRAPH 5

Photograph 6 shows the stimulating effects of hairy vetch on earthworm activity. Fine rooted legumes such as the vetch generally have a stronger effect on earthworms while they are growing than do the tap-rooted legumes such as alfalfa, but the tap-rooted legumes can have a very strong effect after they are incorporated into the soil.

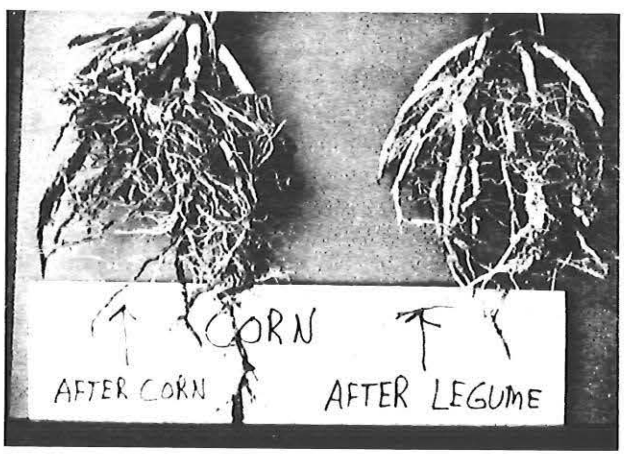


PHOTOGRAPH 6

Poor soil quality appears to go hand in hand with poor root health. Roots need oxygen to grow and they need cracks and holes to grow into. Having good soil structure allows plants to explore and find the nutrients and moisture they need. We have noticed on many occasions that rotations that include too many grain crops not only result in poor soil structure, but also in root rot. This is illustrated by photograph 7 which shows root rot symptoms from a long-term field trial being carried out on the Walworth County farm in southern Wisconsin to compare different farming systems. Where corn followed a green manure of red clover that had been underseeded in winter wheat the previous year, there was a lot less apparent root damage than where corn was grown after corn. Problems with unhealthy roots become strongly apparent in drought years where roots have to more actively seek what they need.

Now it is possible for any farmer to confirm what I am saying on his/her own farm. Fence-rows that are in grass are often good locations for observing optimal soil structure and are often a good standard for comparison with arable ground. Going around the farm with a shovel and looking at what is going on with soil structure and roots can be immeasurably instructive. I will show you an example with soils from an organic farm in central Michigan. These soils samples were taken from a single soil type of a muck soil. This farmer grows small grains and vegetables and raises beef cattle. In Photograph 8 we see soil that has been taken out of a pasture mixture and has been cropped for one year with barley.

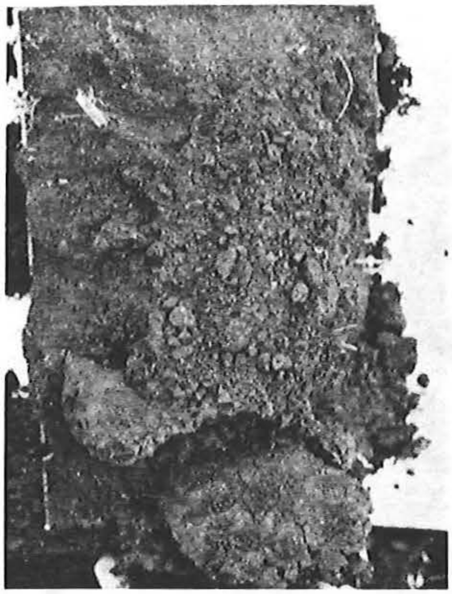
PHOTOGRAPH 7



PHOTOGRAPH 8

In Photograph 9 we see soil from an adjacent field that was in a pasture mix four years before and was cropped for three years with small grains and beans.

PHOTOGRAPH 9



In Photograph 10 we see soil from a nearby field that was in pasture six years before and was cropped with vegetables, small grains, and beans for five years. Note how cropping decreases soil structure and causes the soil to appear finer and packed.

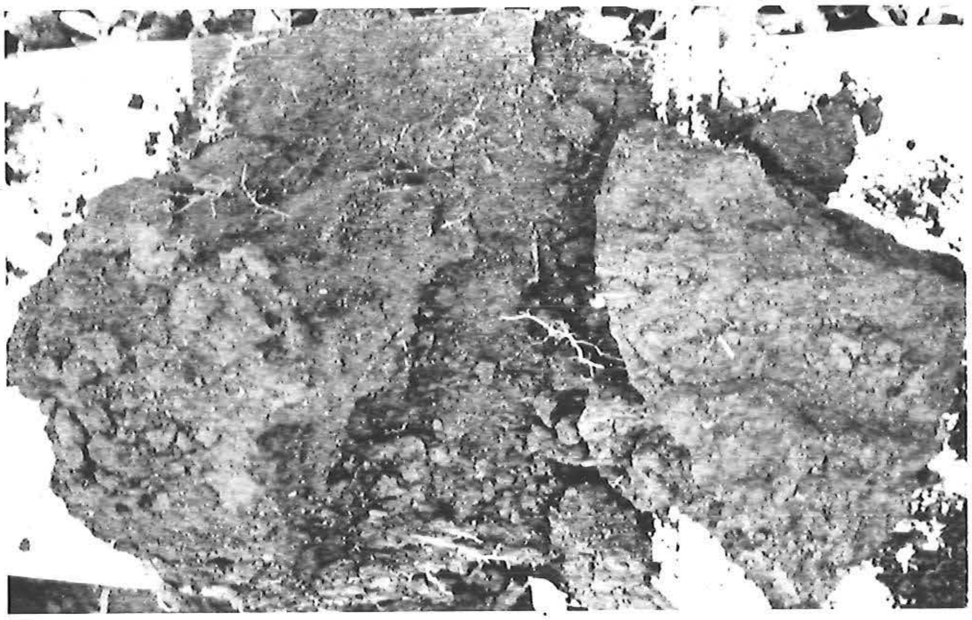
PHOTOGRAPH 10

PHOTOGRAPH 11

In Photograph 11 we see soil from a neighboring field which is in its second year of production in an alfalfa-reed canary grass mixture after having been cropped for eight years. The farmer will leave this mix in for several years to rebuild the soil. Note the appearance of the crumbs again. Usually it takes such a mixture 3-5 years to optimally rebuild soil structure.

Photograph 12 shows soil of the same soil type from a neighbor that is farming vegetables and small grains conventionally, with a full bevy of chemical inputs including mineral fertilizers, herbicides, insecticides, and fumigants.

PHOTOGRAPH 12



I hope that these observations will stimulate you to investigate soils and roots on your own farms. Farmers have been misled by a one-sided, chemical approach to soil fertility. Of course, crops need nutrients, but if soil quality is poor, roots will have a harder time finding both nutrients and moisture due to compaction or disease. Our own observations give us the key that will allow us to supplement a theoretical understanding of nutrient needs with a concrete approach to managing the soil environment.

The soil can teach us a great deal if we observe it. I have not exhausted the subject of soil quality. Assessing crumb structure is one aspect that is easy to talk about. But, perhaps we should also learn again to pay attention to that primal, 'qualitative' experience which farmers have had with the soil's fertility through the ages. This experience lives in our language in descriptions such as: the soil is 'dead', or 'alive'; 'rich' or 'fat', 'dead' or 'burned-out'; it has 'tilth' or has 'gone flat'. We probably all have such experiences, though hardly anyone talks about them. Perhaps if we train ourselves to use them, they too can become a guide for the practical management of fields.

Dr. Walter Goldstein received his B.S. in Botany from the Univ. of Washington, and his M.S. and Ph.D. in Agronomy from Washington State University. He spent four years in Europe working on farms and at research stations testing alternative methods. He has been the research director at the Michael Fields Agricultural Institute since 1986. He directs research projects and continuing education programs for farmers.

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SOIL MICROBES IN AGRICULTURE

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The dry soil of summer, mud in spring and fall, and frozen soil in winter do not appear to be living, but soil is overflowing with life. A pinch of soil contains millions of tiny organisms critical to growing crops. A healthy soil, one full of active microorganisms, is essential to agriculture. Healthy soil produces healthy plants efficient in the accumulation of nutrients, weed control, and erosion control through extensive root systems. The key to healthy soil is the microbial population. The majority of soil microbes are beneficial to plant growth, but they need to be effectively managed, and to do that, we need to understand them better.

Soil is home to large numbers of many different types of microorganisms assembled in complex and diverse communities. The most common soil microorganisms are bacteria, actinomycetes, and fungi. These microorganisms are involved in organic residue decomposition and nutrient cycling. Actinomycetes produce compounds responsible for the rich, earthy smell of a newly plowed field. They are also key players in composting. Many actinomycetes produce antibiotics of the type we use when we are sick. Many fungi are plant pathogens; yet some form beneficial relationships with the root (mycorrhizae). Soil microorganisms are responsible for many important soil processes (Table 1).

Table 1. Benefits from an active soil microbial population

<u>Soil Microorganisms are Responsible for</u>:

1. Decomposition of organic residues
2. Nutrient cycling
3. Assimilation of nitrogen from air
4. Improvement of soil structure
5. Biological control

Microbes are nature's recyclers. When something dies, microbes use the dead material as food for their growth. Microbes break down the large compounds in the organic residue and change them into simpler, smaller compounds. This recycling into simpler compounds provides food for other microbes or plants. Organic matter improves soil physical properties, increases water holding capacity, increases nutrient availability, and acts as a cementing agent for holding soil particles together. Organic matter can be maintained by incorporation of crop residues, crop rotation, and addition of animal and green manures when possible. Addition of organic matter ensures a productive soil and stimulates plant growth by providing food for microorganisms.

Microorganisms help in the weathering process of soil minerals by the mobilization and solubilization of plant nutrients. Microorganisms can alter nutrient solubility making otherwise unavailable nutrients available to the plant by production of organic acids or by microbial uptake. The nutrient cycling processes as regulated by microorganisms are affected by tillage and residue management.

The symbiotic relationship between bacteria and legumes is one of the most widely studied and used plant-microbial interactions. Rhizobia, the bacteria, form nodules on the roots of the legume plant, take N_2 from the air and transforms it into plant-available nitrogen. The plant provides a safe home for the bacteria, while the bacteria gives the plant the food it needs. Inoculation of legumes with rhizobia can add nitrogen to the soil.

Microbes play a major role in the formation of good soil structure. Fungi and actinomycetes produce hyphal threads that bind the soil particles together. The slime produced by bacteria acts as glue to also hold soil particles together. Microbial activity helps aggregate the soil which reduces erosion, allows for good water infiltration and maintains adequate aeration of the soil.

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Microbial activity helps aggregate the soil which reduces erosion, allows for good water infiltration and maintains adequate aeration of the soil.

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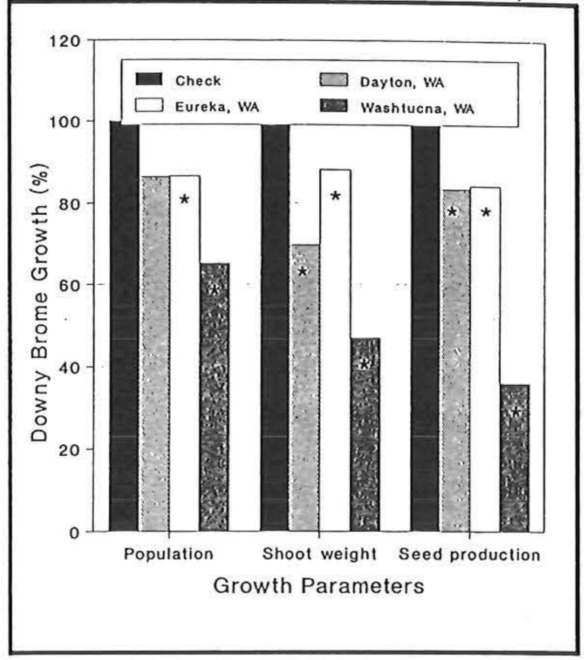
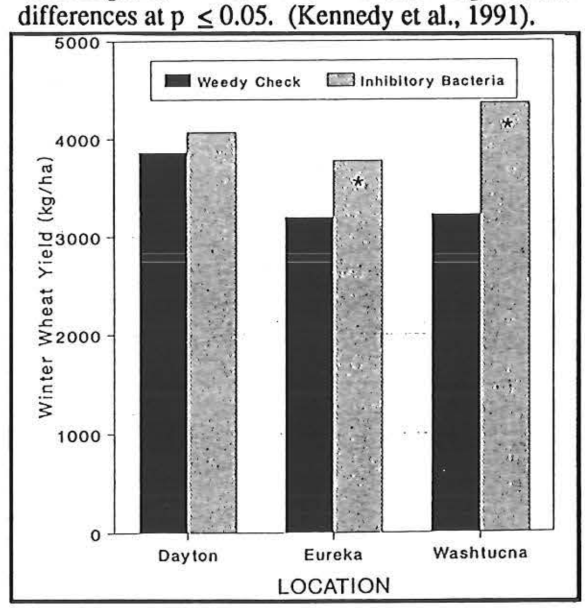
Microbes have the potential to be used in biological control, which is the suppression of one pest by using its natural pest or antagonist. Biocontrol can be used to control insects, pathogens and weeds either by lowering the populations of the pests or by reducing a pest's impact. The microbes function as a direct delivery system for the natural pesticide they produce. There are bacteria and fungi that produce different types of antibiotics that can be used to control many plant pathogens. Inhibitory bacteria that suppress growth of grass weeds but do not adversely affect crop growth can be used to control weeds (Figure 1).

Figure 1. Downy brome growth and seed production from fields inoculated with rhizobacteria and planted to winter wheat at three locations in eastern Washington. Asterisks indicate significant differences at $p \leq 0.05$. (Kennedy et al., 1991).



Even though the weed growth was only suppressed by 20 to 50% in these studies, winter wheat yields were increased by 35% with the application of the bacteria (Figure 2).

Figure 2. Winter wheat population and yield from fields inoculated with rhizobacteria and planted to winter wheat at three locations in eastern Washington. Asterisks indicate significant differences at $p \leq 0.05$. (Kennedy et al., 1991).

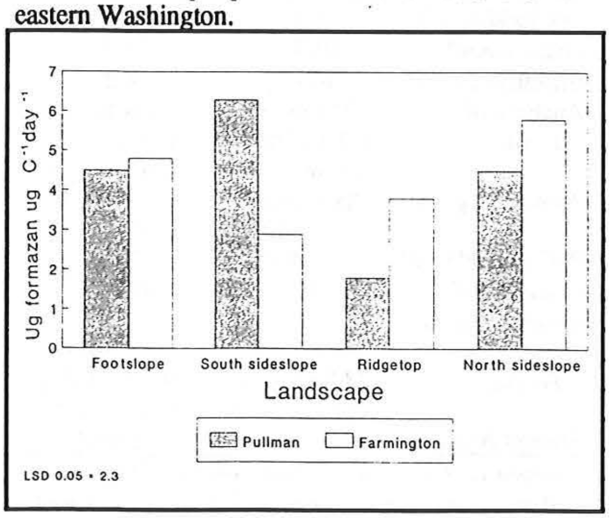


Biocontrol is critical to sustainable agriculture systems, but a greater understanding of the soil microbes and their ecology is needed before biological control can be successfully implemented.

It is hard, however, to understand something you can't see. Soil bacteria, for example, are so small that 1000 of them could be stacked end to end across the period at the end of this sentence. That is a very tiny creature to try to understand, so we have to use indirect methods to find out about these organisms. One way to determine microbial activity is the formazan test. The enzyme being assayed in this test is dehydrogenase, which is involved in the transfer of energy within microbial cells. The formazan test uses the dye triphenyl tetrazolium chloride (TTC), which is the same compound you already may use to test seed viability. TTC, which is clear in solution, can be incubated with soil and will capture the energy or electrons from dehydrogenase. Triphenyl tetrazolium formazan, a bright red color, is then formed and can be used to indicate microbial activity. When the soil is filtered the liquid, the intensity of red in the liquid is an estimate of the microbial activity of that soil.

The formazan test is an important indicator of microbial activity, but microbial activity is often associated with the amount of food available to the soil microorganisms, so soil organic matter needs to be determined as well. The formazan test per unit carbon, or per unit of food available for the microbes, can adequately describe the difference in microbial activities at various landscape positions in two sites in the Palouse region of the Pacific Northwest (Figure 3).

Figure 3. Formazan activity per unit carbon across landscape position at two locations in eastern Washington.



Microbial activity per unit carbon was lowest in the ridgetop soil and highest in footslope soils. The formazan test, however, does not indicate the types of soil microorganisms present and it cannot discriminate between beneficial organisms or pathogens. We also know that test values will change with time or season in which the samples are taken. Caution is needed before you change management practices based solely on this test.

Soil microbes carry out many beneficial functions. Many of these activities center around the decomposition of organic residues and nutrient cycling. Sustainable agriculture will not truly succeed unless the soil microbial population dynamics and ecology are considered and managed effectively.

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Dr. Ann Kennedy received her B.S. in Botany and M.S. in Agronomy from the Univ. of Missouri and her Ph.D. in Soil Science from North Carolina State University. She is investigating the role of soil microorganisms in sustainable agriculture. She has developed the use of naturally-occurring weed-suppressive bacteria to control grass weeds. Dr. Kennedy is developing principles and methodologies to understand the microbial component of soil quality to improve human nutrition and preserve our natural resources of soil and water.

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

Project Description

Compost improves moisture retention, pore volume, structural stability, and erosion resistance of soils. Aerobic soil microorganisms create compost or humus by digesting raw materials (e.g. manure, straw, bedding materials, corn stalks, crop residues, yard wastes, etc.). Composting is most efficient on materials with a carbon to nitrogen ratio (C:N) of 20-30:1. The compost pile must be turned to provide air for microbial activity. This project uses a flail-type turner.

The composting process occurs within a temperature range of 130 to 160°F with an optimal moisture content of 40 to 60%. The heat generated during composting is believed to kill disease pathogens, reduce weed seed viability and weed levels. Compost has higher concentration of soil nutrients and weighs less than raw manure; it can be spread at a lower rate. Composting reduces volume of raw material (bedding, straw, manure, etc.) by about 50%.

Demonstration plots have been set up to determine the value of on-farm composting of animal manures. Compost will be compared to liquid and raw manure in the following areas: soil fertility, weed counts, yields, profitability and nitrate movement.

The compost in this project is made primarily from pen-packed manure that contains a significant amount of straw bedding. One of the participants also includes some yard scrapings in his composting pile. The material is placed in windrows measuring 12' wide x 6' high. These windrows are stirred, turned and aerated using a Wildcat compost turner. Frequency and timing of the turnings determined by the temperature of the compost pile - which is measured with candy thermometers inside copper tubing placed deep within the windrow. The project cooperators try to keep temperatures above 125°F, although that was not always practical. Usually, the composting process would be completed after 5 or 6 turnings.

One of the main goals of this project was to demonstrate the feasibility of composting for the average farmer and to arrive at some estimates of the time, energy, and economic inputs necessary for composting.

Highlights from 1990

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). Results after first year of application are shown in the table.

Compost Vs. Manure - 1990

	Manure	Compost
	-----Vander Ziel Farm[a]-----	
Oat Yield (bu/A)	83.6	91.8
Grass weeds[b]	30.8	17.3
Broadleaf weeds[b]	8.5	7.2
Analysis of Fertility[c]	357 lbs N	155 lbs N
	183 lbs P_2O_5	104 lbs P_2O_5
	469 lbs K_2O	271 lbs K_2O
Amount Applied	25.5 ton/A	12.7 ton/A
	-----Gleis Farm[d]-----	
Barley Yield (bu/A)	50.4	50.4
Grass weeds[e]	87	105.8
Broadleaf weeds[b]	16.5	23.5
Analysis of Fertility[c]	63.8 lbs N	56.7 lbs N
	22 lbs P_2O_5	39.6 lbs P_2O_5
	52.8 lbs K_2O	74.6 lbs K_2O
Amount Applied	2200 gal/A	3.3 ton/A

[a]Compost vs. Raw Manure; [b]Number per 4 ft^2; [c]Analysis of total applied manure or compost; [d]Compost vs. Liquid Manure; [e]Number per 1 ft^2

Highlights from 1991

Two more cooperators joined the project. The cooperators experimented with using only front end loaders - equipment most farmers already own - to produce compost. Soil laboratory testing did not provide a clear, standardized analysis of compost.

Analysis of Fertility Applied (per acre)

Farm / *Crop*		Amount Applied	N (lbs)	P (lbs)	K (lbs)
VanderZiel	Compost	7.7 T*	172	114	197
Corn	Raw	11.6 T	130	53	213
Gleis	Compost	5 T	141	103	145
Corn	Liquid	3000 gal	90.6	26.7	69.3
Schelhaas	Compost	12.7 T	257	168	290
Corn	Raw	10.8	167	121	180
Schaap	Compost	9 T	170	135	153
Alfalfa	Raw	5.5 T			
	Commercial	200 lbs	18	46	62

*T=tons

Yields and Cost Estimates[1] of Composting, Manure, and No-Fertilizer Check (Corn @ $2.25/bu)

	Compost	Manure[2]	Check	Chemical N-P-K
Vander Ziel - Corn				
Yield (bu/A)	107.2a[3]	100.6b	91.7b	
Gross ($)	241.20	226.35	206.32	
Prod. Cost $	44.40	40.50	-0-	
Net Income	196.8	185.85	206.32	
Gleis - Corn				
Yield (bu/A)	113.4a	118.0a	94.7b	
Test Wt (lb/bu)	56.25	56.1	54.25	
Gross ($)	255.15	265.50	213.08	
Prod. Cost $	58.60	139.23	-0-	
Net Income	196.55	126.27	213.08	
Schelhaas - Corn				
Yield (bu/A)	61.8a	63.4a	66.7a	
Schaap - 3rd cutting alfalfa				
Yield (lbs/A)	1,678	1,497	1,497	1,860

[1]Estimates do not include labor.
[2]Raw Manure on Vander Ziel, Schelhaas, and Schaap farm; liquid manure on Gleis farm.
[3]Averages marked by different letters are statistically different at $\alpha=0.05$.

Impact of Compost on Weeds

Project participants were most impressed by the consistently lower weed counts in composted plots. This can potentially reduce the need for herbicide and tillage. Composted plots had fewer grass weeds on three different farms. There were fewer broadleaf weeds on composted plots in 2 out of 3 farms.

Weed Counts in Corn - 1991

	Compost	Manure[1]	Check[2]
Gleis			
Grass	9.0	15.1	11.9
Broadleaf	1.3	1.9	3.3
Schelhaas			
Grass	8.3	11.7	9.7
Broadleaf	2.8	4.1	2.2
Vander Ziel			
1st Count			
Grass	85.2	76.8	89.0
Broadleaf	14.5	15.5	17.2
2nd Count			
Grass	13.2	21.2	19.4
Broadleaf	3.2	3.4	2.4
3rd Count			
Grass	14.9	13.0	9.7
Broadleaf	2.5	2.7	2.2

[1]Raw manure on Vander Ziel and Schelhaas farm; liquid manure on Gleis farm
[2]No Fertilizer Control

Analysis of Leaching Potential

Soils were tested directly underneath and around compost sites to determine levels of leaching. There appears to be less leaching of N, P, K on compacted sites.

Other Observations

Composting manure takes a little extra time, but is worth the effort. With the right equipment, compost can be spread more evenly and at a lower rate than raw manure.

Highlights from 1992

In the fall, prior to a light fall tillage, compost was applied to the test plots. There were also test strips of raw manure and control plots with no fertilization. A late spring snow storm delayed the planting of oats/alfalfa, and a large tornado in June did a lot of damage to this area and forced the farmers cooperators to scale back on the demonstration project. Cold, wet weather and dark skies throughout the rest of the summer reduced crop yields on all the plots. Weeds, however, flourished this season.

On VanderZiel's and Gleis' plots, the treatment plots were altered so that no-fertilizer control plots in 1991 were located on fields which had received manure or compost applications in 1990. The fertility level and yields may be higher than expected because of residual nutrient levels (Soil test results show no differences between control plots and manure or compost plots.)

Results of Compost, Manure, and No-Fertilizer Check on Oats in 1992

	Compost	Manure	Check
		Vander Ziel	
Yield (bu/A)	43	34	39
Test Weight (lb/bu)	37.6	35.3	36.3
Application rate	5.4 T/A	17.1	-0-
Analysis of Fertility	97.2 lb N 75.6 lb P 113.4 lb K	307.8 lb N 188.1 lb P 359.1 lb K	
Grass weeds	38.1	46.3	36.4
Broadleaf weeds	4.1	7.3	3.8
		Gleis	
Yield (bu/A)	76.3	72.9	51.5
Application rate	6.5 T/A	3000 gal/A	
Analysis of Fertility	104 lb N 117 lb P 143 lb K	117 lb N 45 lb P 99 lb K	
Grass weeds	67	54.6	58.9
Broadleaf weeds	2.5	51	2.1
		Schelhaas	
Yield (bu/A)	70.7	69.4	74.6
Test Weight (lb/bu)	38.75	38.5	38.5
Application rate	7.2 T/A	6.6 T/A	
Analysis of Fertility	172.8 lb N 144 lb P 252 lb K	99 lb N 66 lb P 165 lb K	
Grass weeds	62	154.4	77
Broadleaf weeds	5.9	3.9	3.6

Results of Compost, Raw Manure, Commercial Fertilizer on Alfalfa in 1992

	Compost	Raw Manure	Commercial Fertilizer	Check
Amount applied[1]	9.1 T/A	5.5 T/A	200 lb/A	-0-
Yields (tons/acre)				
2nd cutting-1991	1.24	1.24	1.24	1.24
3rd cutting-1991	0.84	0.75	0.93	0.75
1st cutting-1992	2.00	1.82	1.82	1.09
2nd cutting-1992	2.18	1.63	1.63	1.45
3rd cutting-1992	2.36	1.63	1.36	1.36
Total Yields '91-92	8.61	7.07	6.98	5.89
RFV[2]	153.15	136.06	154.33	154.72
Crude Protein (dry wt)	20.27	19.6%	20.07	19.73
ADF (dry wt)	33.10	34.51	34.51	32.79
NDF (dry wt)	38.28	42.45	37.40	38.1

[1]Alfalfa planted in spring of 1990. All fertilizer applied on 6-21-91 after first cutting; [2]Relative feed value - forage samples were tested for nutrient value after 3rd cutting in 1992. RFV predicts relative intake of digestible energy. Forages with RFV>150 are considered excellent quality. Crude protein (CP) is a measure of the total protein (available and unavailable) in the forage. ADF and NDF represent acid detergent fiber and neutral detergent fiber, respectively. ADF and NDF are negative predictors of digestibility and intake. Forage containing >20% CP, <30% ADF, and <40% NDF are considered to be of relative high quality.

In the alfalfa plot, the soil amendment value of compost and manure was longer lasting than that of commercial fertilizer as seen by the higher yields after multiple cuttings.

Management Tips

1. "Soft" manures may be piled with a loader and easily turned. More compacted and heavily bedded manures will turn 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.

3. Use adequate bedding to keep carbon:nitrogen at 20-30:1 range. When hauling the manure out and piling it in rows, if done through the beaters of a spreader, it should heat up right away. These can be left until the temperature starts to drop slightly before turning. Using a skid loader with a tine bucket to turn piles over works very well. The tines help break up chunks and blends the material as it gets rolled over.

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

5. 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.

6. 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.

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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: *Address*	Carmen M. Fernholz Route 2, Box 9A Madison, MN 56256	*Tel:* *County:*	612-598-3010 Lac Qui Parle
Cooperators:	Jim Tjepkema - Rodale Research Coordinator Audrey Arner - Land Stewardship Project Craig Sheaffer - Professor, U of M	*Enter-prise*	grain, hogs

Project Description

Soil fertility for a corn crop is usually maintained with NPK fertilizer application based on soil test recommendations. Soluble nitrogen fertilizer that is not immediately taken up by plants is prone to leaching which contributes to groundwater contamination. Organic sources of nitrogen (from plants or animals) tend to be more stable and release more slowly into the soil and are better for the environment if managed properly.

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.

Highlights from 1990

Soil tests were made to determine initial fertility before nitrogen treatments were applied.

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

Highlights from 1991

Soils were tested after oat harvest in December to see if the different fertility sources used would be reflected in soil analyses.

Soil Test Results after First Growing Season of Oat

	NITRO	Urea	Manure
N - lbs/A	14.0	13.0	17.0
P (Olson) - lbs/A	8.0	8.0	12.0
K - lbs/A	388	361	406
pH	6.9	7.0	6.9
Organic Matter	3.3	3.4	3.4

Heavy rains made it difficult to mechanically cultivate the plots. Excessive moisture reduced corn yields.

Highlights from 1992

Economic Analysis of Different Fertility Sources on Oats , Corn, Soybeans

	NITRO	Urea	Manure
		OATS 1990	
Yield	55.7	56.3	53.7
Gross Income	$58.49	$59.12	$56.39
Seed	29.00	2.00	2.00
Fertilizer	12.50	12.50	-0-
Net Return	**16.99**	**44.62**	**54.39**
		CORN 1991	
Yield*	46.1	67.0	72.2
Gross Income	92.20	134.00	144.40
Seed	20.48	20.48	20.48
Fertilizer	0	25.26	0
Moisture	24.3	22.1	22.6
Test weight	49.8	51.9	52.1
Feed analysis- Crude protein (%)	8.13	7.85	8.10
Net Return	**71.72**	**88.26**	**123.92**
		SOYBEAN 1992	
Yield	24.8	26.9	29.3
Gross Income	124.00	134.50	146.50
Seed	15.63	15.63	15.63
Net Return	**108.37**	**118.87**	**130.87**
3 YR NET	**197.08**	**251.75**	**309.18**

*Heavy rains through June, July and August reduced corn yields.

The figures from the table above reflect only those input variables that were not similar in all of the treatments with one exception: costs for applying the liquid manure and for custom applying the dry fertilizer.

All other costs would be exactly the same for all three treatments. Test weights and moisture percentages were all similar except for the corn crop. An additional cost to be calculated would be the drying cost differences based on the varying moisture percentages.

Conclusions

1. Manure treatments have thus far resulted in the highest yields for oat and corn crops.

2. NITRO alfalfa apparently does not provide adequate nitrogen to oat and corn.

3. These alternative nitrogen systems decrease dependence on fossil fuels, as well as reduce ground water contamination opportunities.

4. Alternative systems help diversify opportunities for production management.

5. Fernholz has decided to continue this study for at least another 3 year cycle to determine any further differences.

Management Tips

1. Use manure analyses to help determine how much manure should be applied to the soil.

2. If you choose to use NITRO alfalfa, seed it at a minimum rate of 15 lbs/A and try to get at least one cutting to help cover costs. Seed nurse crop at as low a rate as is economically possible.

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Project Title:	**Manure Management/Utilization Demonstration**	*Time Span:*	April 92 to March 94
Principal Investigator:	Timothy Arlt Minnesota Extension Service- Steele County	*Tel:*	507-451-8040 ext. 250
Address	590 Dunnell Drive PO Box 890 Owatonna, MN 55060-0890	*County:*	Steele, Rice, Mower, Freeborn
		Enter-prise	corn, soybeans, dairy, beef, hogs

Project Description

Proper manure management will result in economic benefit and reduce the risk of polluting the environment. Though manure is prone to run-off or nutrient leaching when applied at excessively high rates, many farmers are often reluctant to use lower rates because they think that crop yields will be reduced. This project will hold a series of demonstrations and practical clinics to show farmers how to properly utilize this valuable resource.

Highlights from 1992

The project consists of 4 demonstrations and development of a videotape.

1. Low rate of manure in corn production - 3 demo-research sites were initiated in Rice, Steele & Mower counties. Nine treatments were evaluated. They included the farmer rate, 1/2 the farmer rate injected with tines & sweeps, 1/2 rate broadcast, 2 treatments with N Serve and 2 commercial fertilizer treatments.

2. Proper utilization of turkey manure. Cooperators looked at incorporation methods to prevent phosphorus runoff on 'highly erodible land'.

3. Manure calibration clinics. Over 100 people attended the clinics and most farmers were shocked to learn that most spreaders apply much higher rates than assumed.

4. Four farmers will participate in whole farm manure management demonstrations. Soil and manure samples were taken from each farm.

5. A videotape for Manure Calibration is being produced for this fall.

Project Results

Turkey Manure Utilization. At the Rice County site there was response to all manure and fertilizer treatments. Commercial fertilizer treatment showed significantly higher yields than the manure treatments at the Steele County site. The plants showed N stress at these plots. Perhaps the cool weather, higher organic matter and clay content of the soil tied up available N. Calibration clinics were held in each county, but no data was collected. Four different spreaders were calibrated; the average amount applied was about 30 tons/acre. At this rate, there was more than enough nutrients for crop growth.

Calibration Clinics - Manure Test Results

Cooperator	N	P	K
	lbs nutrients per ton		
Troska	38	16	18
Sayles	38*	19*	27*
Parmenter	32	15	33
Sammon	40	16	15
Noble	47	23	58

*lbs of nutrients per 1000 gallons

Spring soil test results and estimated nutrient contribution from turkey applications in field demonstrations,

Location	Morristown	Medford
Soil Type	Clarion-Storden loam	Max Creek silt
	Soil Test	
Organic Matter	Medium	High
P (ppm)	32	20
K (ppm)	166	119
	Estimated manure nutrients applied*	
N (total) - lb/A	360	292
N (avail) - lb/A	184	150
P (lb/A)	432	351
K (lb/A)	264	214

*First year availability based on 30% organic N, 100% inorganic N contents.

Observations

Manures are a good source of nutrients. If farmers test manure for N-P-K and calibrate spreaders, nutrient management plans can be devised for all farms. In the case of one manure calibration clinic cooperator, producing 1,000,000 gallons of manure annually, this was enough manure to provide all the nutrient needs for about 100 acres of corn. This would reduce the amount of fertilizer needed to be purchased by 19,000 lbs of N, 20,650 lbs of P_2O_5, and 22,500 lbs of K_2O. Substantial savings of input costs to crop production.

Management Tips

1. Farmers should be calibrating spreaders so that they know the rate being applied. The majority of farmers do not know this information.

2. Manures on 'highly erodible land' need to be incorporated to prevent nutrient loss through runoff. Disking or field cultivating is adequate to incorporate manure.

3. Little phosphorus is moved in the soil and incorporation does not move P beneath 4 inches into soil.

Location of Project

Contact Tim Arlt, Steele County Extension office for specific locations.

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Project Title:	**Taconite as a Soil Amendment**	*Time Span:*	March 92 to November 93
Principal Investigator: Address	Donald E. Anderson RR 1, Box 40 Gary, MN 56545	*Tel:* *County:*	218-584-5586 Norman
		Enterprise	corn, alfalfa

Project Description

This project looks at using taconite tailings as a soil amendment. The tailings are magnetic and are believed to affect the water holding capacity of the soil. The theory is that water will be attracted to the magnetic taconite particles which have been added to the soil. Water will then be more available for the crop plants.

Anderson is comparing taconite with fertilizers. Yield, cost comparisons, and nutritional value of the crops will be compared with taconite, fertilizer and control plots on three fields to determine if using taconite is a beneficial amendment to the soil.

Project Results

Field A had strips of 4% taconite applied at a rate of 250 lbs per acre in 1985. Fields B and C had 500 lbs of 26% taconite applied in strips in 1992.

In 1992 Field A was planted to corn. This field has had no fertilizer applied since 1984 in the strips that have the taconite applied. Fertilizer was applied at recommended rates in the fertilizer strips.

Field B was planted to corn in 1992. No fertilizer on the taconite and control strips.

Field C had was seeded to alfalfa overseeded with oats in mid July of 1992 with 500 lbs. of 26% taconite in strips

The yields and quality of the grain were poor in the 1992 season because it was cold and dry at the beginning and cold and wet at the end. Field B was too wet to harvest as grain and was chopped as forage and no results were gathered. Field C was just being established as an alfalfa field so results will not be available until the 1993 season. Field A was the only field that any comparisons could be gathered. Data from this plot showed that taconite had an advantage over fertilizer this year.

Corn Moisture , Test Weight, and Yield Results From Field A

	Moisture	Test Weight	Yield (bu/acre)
Nothing added (near taconite)	36.78%	38#	31.0
Nothing added (near fertilizer)	37.90%	36#	30.5
Fertilizer	35.66%	38#	39.5
Taconite	39.78%	38#	59.2

Cost Comparison between fertilizer and Taconite on Field A

The fertilizer was applied at recommended rates and cost $23.83/acre. The corn yielded 39.5 bu/acre. Corn prices of $2.00 per bushel gave a return of $55.12/acre (using only fertilizer costs).

The taconite was applied in 1985 at 250 lbs/acre and cost $1.63/acre or $13.00/ton. This cost divided by the seven years since applied cost $.23/acre. The corn yielded 59.2 bu/acre in 1992. This gave a return of $118.17/acre (using only the taconite costs).

The grain was tested for nutrient quality and no difference was found in the feed value between the taconite plots and the fertilizer plots.

Location of Project

From the junction of highways 32 and 200 (south of Gary) go east 4 miles, turn right on Cty. 34, go 1 1/2 miles south, farm on the right side.

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Project Title:	**Integration of Nutrient Management Strategies with Conservation Tillage Systems for Protection of Highly Erodible Land and Lakes in West Otter Tail County**	*Time Span:*	April 92 to March 95
Principal Investigator: *Address*	Harold J. Stanislawski Minnesota Extension Service Otter Tail County Courthouse Fergus Falls, MN 56537	*County:*	Otter Tail
Cooperators:	Farmers: Dan Jennen, Orland Ohe, Dave Holt, Everett Gilbertson, Julian Sjostrom	*Enterprise*	Corn, Soybeans, Small Grains, Dairy

Project Description

Agriculture and tourism are the two main industries in this county. It is vitally important to maintain the lake quality in this region as well as farming opportunities. However, some farmers here rely heavily on commercial fertilizers as well as moldboard plowing on 'highly erodible land,' (HEL) which exacerbates soil erosion as well as leaching and runoff of nitrogen, sediments and phosphorus to lakes and to groundwater.

Several farmer cooperators have been enlisted to participate. The objectives of this project are to:

1) Maintain a 30% soil cover by crop residue on HEL and examine the impact on pesticide runoff or leaching, nitrogen, diesel fuel and other inputs.

2) Properly use animal waste on HEL to reduce runoff.

3) Reduce soil loss on HEL from the current 16 tons per acre by 33%.

4) Develop 3-yr crop rotation of wheat, corn, beans using conservation tillage.

5) Evaluate buffer strips near lakes.

Project Results

Replicated on-farm filed plots were set up to evaluate chisel vs. no-till systems, or disc vs. no-till system.

Results of Otter Tail County Project

Farmer Crop		No-Till	Disc
Ohe	yield (bu/A)	16.58	19.54
soybean	costs ($)[1]	116.00	122.00
	BEP ($/bu)[2]	7.00	6.24
Gil	yield (bu/A)	55.86	55.72
wheat[3]	costs ($)	105.3	107.30
	BEP ($/bu)	1.88	1.93
		No-Till	Chisel
Holt	yield (bu/A)	47.39	48.54
wheat[3]	costs ($)	101.78	104.79
	BEP ($/bu)	2.14	2.16
Jennen	yield (bu/A)	64	68
corn[4]	costs ($)	160.87	179.70
	BEP ($/bu)	2.51	2.64
Sjostrom	yield (bu/A)	60.11	62.93
corn	costs ($)	137.39	148.89
	BEP ($/bu)	2.28	2.36

[1]Costs of production includes seed, fertilizer/manure, planting, chisel/cultivation, chemicals, land, harvest; [2]BEP=Breakeven Price (selling price of grain) needed to cover cash costs; [3]Wheat on soybean stubble; [4]Corn on wheat stubble

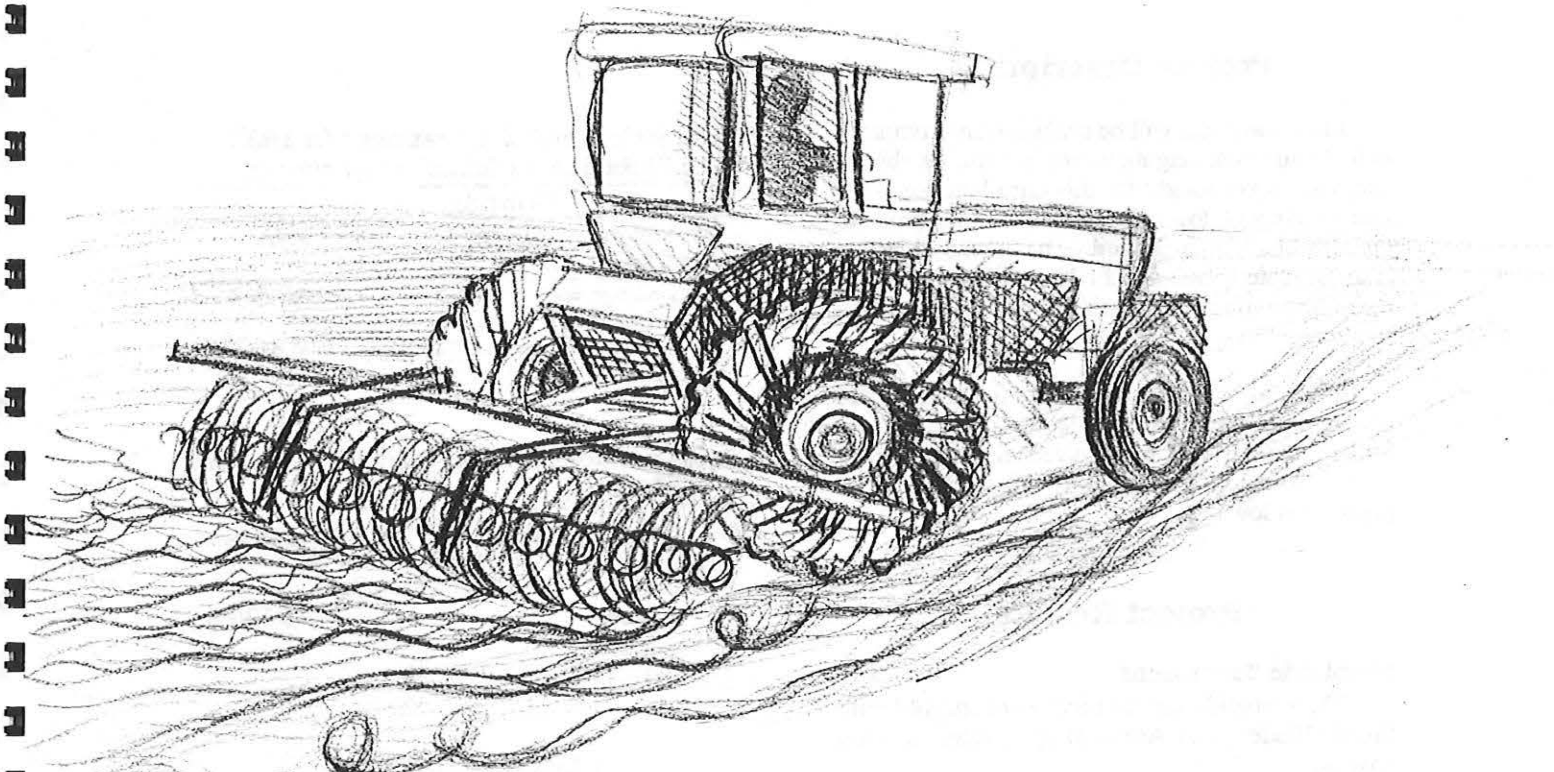
ESAP Staff Notes:

Most of these farmers lost money because the average price that farmers received for corn and soybean in 1992 was not enough to cover the production costs. The Northwestern Minnesota Farm Business Management 1992 Report estimated that the average price received were:

corn	*$1.93/bu;*
soybean	*$5.21/bu;*
spring wheat	*$3.14/bu.*

The fertilizer costs in these plots ranged from $0 - $28.42/acre, averaging $18.10/acre. The chemical costs ranged from $2.64 - $35.88/acre, averaging $15.57/acre. Farmers who want to be profitable in these systems need to take a good look at ways to reduce their fertilizer and chemical inputs.

Weeds and Insects.....



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Project Title:	**Fine-tuning low-input weed control**	*Time Span:*	March 91 to October 93
Principal Investigator: *Address*	David Baird Wilder Forest 14189 Ostlund Trail N. Marine, MN 55047	*Tel:* *County:*	612-433-5198 Washington
		Enter-prise	corn, soybean, oat, hay, cattle, sheep

Project Description

Two non-chemical weed control methods using Bezzerides tools and combinations of rotary hoeings were evaluated for corn and soybeans in ridge-till and conventional tillage (combination of moldboard plow, chisel plow and/or disc) systems. The trials consisted of 5 similar experiments each year of the project.

1991 Design and Results

In the first three experiments, weed control in conventionally tilled corn following red clover, green manure or alfalfa/grass hay (Experiment 1), ridge-tilled corn following soybeans (Experiment 2) and ridge-tilled soybeans following soybeans (Experiment 3) consisted of:

Treatment A: rotary hoe and ridge-till cultivation only
Treatment B: rotary hoe and ridge-till cultivation plus Bezzerides tools

In the fourth and fifth experiments, weed control in conventionally tilled corn (Experiment 4) and ridge-till soybeans (Experiment 5) consisted of:

Treatment A: single pre-emergent rotary hoeing
Treatment B: double pre-emergent rotary hoeing

Treatments were replicated four times in 4 row plots with row lengths of 800 to 1,400 feet, depending on field length.

There were no statistically significant differences in the yields of any of the five experiments. Weed control was poor due to large populations of quack grass and foxtail throughout the experimental area and the late planting and cultivation dates because of the wet spring. Yield differences were greater due to deer damage, pockets of extra heavy weed pressure, and field variation rather than treatment differences.

Experiment	Treatment	Weed Rating*	Yields
1	A	3.7	105.1
	B	3.5	108.9
2	A	5.0	—
	B	5.0	—
3	A	4.5	25.9
	B	4.75	25.0
4	A	3.5	112.4
	B	3.75	112.8
5	A	4.0	16.7
	B	4.25	15.0

*Weed ratings: 1-excellent control, 2-good, 3-average, 4-poor, 5-significant yield loss.

1992 Design and Results

The experiments this year consisted of weed control in primarily conventionally tilled corn. In the first three experiments, weed control in conventionally tilled corn following red clover, green manure or alfalfa/grass hay (Experiment 1), conventionally tilled corn following small grains (Experiment 2) and ridge-tilled soybeans following corn (Experiment 3) consisted of:

Treatment A: rotary hoe and ridge-till cultivation only
Treatment B: rotary hoe and ridge-till cultivation plus Bezzerides tools

In the fourth and fifth experiments, weed control in conventionally tilled corn following hay (Experiment 4) and conventionally tilled corn following small grains (Experiment 5) consisted of:

Treatment A: single pre-emergent rotary hoeing
Treatment B: double pre-emergent rotary hoeing

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Project Title:	**Biological Weed Control in Field Windbreaks**	*Time Span:*	Summer 1991 to Fall 1993
Principal Investigator: *Address*	Tim Finseth Marshall County Soil and Water Conservation District P.O. Box 74, Warren, MN 56762	*Tel:* *County:*	218-745-5010 Marshall
		Enter-prise	small grains, row crops and trees

Project Description

Field windbreaks help protect soil from wind erosion. Establishing trees for windbreaks is often difficult because weed overgrowth choke out the tree seedlings. Weeds in field windbreaks also have a tendency to spread into the cropped fields. Herbicides and tillage are normally used to control weeds in field windbreaks but sometimes end up damaging tree seedlings. An alternative weed control that reduces costs of chemical, fuel, labor and equipment would allow windbreaks to be a more attractive option to farmers.

Rye contains allelopathic properties which inhibit weeds. The weed management strategy explored in this project is to plant rye strips in the fall and plant the trees into the rye in the spring. After the trees are planted in the designated area, a comparison will be made with trees planted using conventional weed control, which involves tillage and herbicides. The planted trees will be monitored for survival rates, growth rates, and health. Also, an inventory of weeds will be made to assess the effectiveness of rye as a weed control agent.

Project Results

Tree planting sites were summer fallowed in 1991. In the fall of 1991, 12 foot wide strips of rye were planted. In the spring of 1992, the trees were planted into the rye strips. In the fall of 1992, one of the test sites required rotary hoeing because of heavy weed competition. We are hoping that rye will voluntarily come up again in 1993. If not, the area will need other methods of weed control. The second test site is going according to plan.

Observations

Rye crop does not grow well during wet falls. It is susceptible to drown out. Site #1 had this problem because it is situated on very heavy soil with slow percolation. Site #2, which has lighter soil with better drainage and faster percolation, appeared to be doing well with the rye crop. There was one small area that had very light kochia and one small area that had very light quack grass. The most significant observation was that the trees seemed to do very well planted in rye.

Unfortunately, when the landowner did his fall tillage on Site #2, gophers moved from the field to the rye strips. They ate off the tree roots and there are no survivng trees.

Early results show that rye, under the right conditions will reduce weed levels so that chemicals will not be necessary.

Estimated Cost Savings

Conventional weed control (mechanical and chemical) costs range from $50 to $150 per 1/2 mile. (Many producers have five or more miles of windbreaks, therefore, the cost of weed control can be substantial.) The cost of the rye strips may be as low as $10 per 1/2 mile.

The rye would also protect the trees, perhaps improving the survival percentage which reduces costs of re-planting trees - which is approximately $200-$250 per half mile.

Management Tips

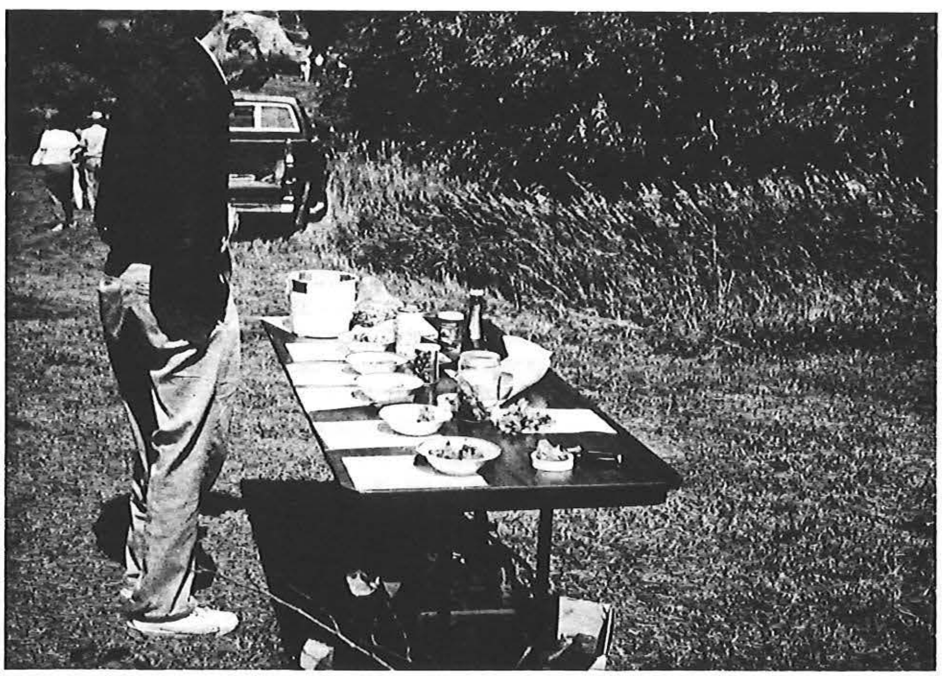
The rye needs to be planted by September 1 (in northern Minnesota). It can not exceed 1/2 bushel per acre. When the rye is too dense, it will compete with the trees.

Location of Project

Site #1 - From Warren, MN - 2 miles on Hwy 1, 1-1/4 miles north on Cty 104. East side of road.

Site #2 - From Warren, MN - 9 miles east on Hwy 1, 3/4 mile south on township road. West side of road.

Alternative Markets.....



Don't get me wrong: cost-containment is a viable and necessary strategy for encouraging producers to become "sustainable" producers, and it will help many to remain as viable, cost-competitive producers while simultaneously yielding environmental benefits. But this by itself is not enough. Producers thinking about sustainable systems must also make the transition to a market-oriented mentality and invest significant time in becoming marketers of the products of sustainable agriculture as well.

Sellers or Marketers?

My favorite definition of marketing states that it is "the process of finding cost-effective solutions to someone else's problems" I like the definition because it places the focus clearly on "someone else"; the marketer is actively involved in identifying (or creating!) needs to be fulfilled in the marketplace. When carried to a successful conclusion, the question is changed from "What can I get for it?" to "Here's what I need from you in order to make you happy." Obviously, the issue of price is not a mere tag-on to the transaction; after all, all solutions must be "cost-effective." Nonetheless, a marketer is able to add whole other dimensions to the transaction by introducing concepts of quality, service, and uniqueness, among others.

In my mind, sustainable producers should seek to be marketers of special products rather than only clerks selling low-cost goods. But if this is to occur, then significant additional changes and investments must be made by producers.

Can farmers capture added value?

Today, 24¢ of every food dollar goes to the farmer, 76¢ goes somewhere else. Cost increases of paper for packaging, fuel for transportation, or pay raises for manufacturing employees have far more impact on the ultimate retail price than crop prices received by farmers.

If sustainable producers are to gain a greater share of the retail dollar (as either a reward for greater risk in production or for greater productive ingenuity), then they must:

- Identify existing customer needs, and create new ones.
- Communicate to customers how sustainable products meet those needs.
- Organize themselves to consistently, cost-effectively exceed customer expectations.

Identifying and creating needs

Obviously some consumer needs have already been identified and at least partially exploited by sustainable producers. A few examples, ideas and caveats.

There is a segment of our society who, for medical reasons, find themselves to be highly chemically sensitive. In addition to housing and clothing, diet is a critical issue for such individuals. Issues such as pesticide use on produce and sub-therapeutic use of antibiotics in meat production are important to these individuals. Producers who can supply appropriate products have a captive audience.

Other consumers feel divorced from the system that supplies their food. To connect with that system, they seek out producers who will be "their" farmers - real people with real names and families and "real" food. (Their words, not mine). A variation on this theme are those adults who remember their own days on the farm, and want to get food that tasted as good as that which Grandma and Grandpa produced, or who want children to know that strawberries do not grow in green plastic containers, and milk is not produced in the dairy case. You'll find these folks at farmers markets and PYO farms. They aren't necessarily looking for the products of sustainable agriculture. But the fact that they like to talk to farmers gives sustainable producers a better chance to communicate their story, and in so doing, create long-lasting customers.

Finally, there are consumers who have made value choices that compel them to use their personal purchasing power to support particular production systems. The choice may be to eat organic produce and grains so as to support farmers who forego the use of synthetic pesticides and fertilizers, and so improve the environment. Or it may be to prefer free-range poultry so as to support producers who provide a certain level of animal welfare. I do not suggest that such values are right or wrong. But from a marketing standpoint, such choices represent customer needs and producer opportunities. Persons who wish to be marketers will approach such situations accordingly.

Communicating with consumers: accessing the mainstream

These examples identify specific niches already existing for sustainable producers. While, small, they do exist and are growing. Are there distribution system requires higher retail prices than mainstream consumers are willing to pay.

Rate of growth is almost impossible to estimate since statistics are virtually non-existent. Only an estimated 1% of all fresh produce sold in the U.S. is organically-produced. Nonetheless, that minuscule market share represents several million dollars in sales. Perhaps contrary to common perception, fresh produce is not the major area of activity currently. The trade indicates that growth is in grains, processed foods and non-food products.

I believe organic production offers long term opportunities for Midwestern producers, but these opportunities will take time and collaborative effort to develop. Producers must start small, learn to deal with the added production risks, learn the markets, and grow over time. No get-rich-quick, ride-the-crest-of-the-wave schemes here. More specifics in a moment.

Integrated Pest Management Programs: IPM is another color of the sustainable agriculture spectrum. It is more mainstream from a production standpoint because it embodies the common sense ethic of using all cultural controls possible to prevent pest problems, yet it allows use of synthetic chemical controls when pest pressure and potential economic damage warrant. The IPM concept in some areas is being written into statute and rule, such as the concepts of best management practices for nitrogen or atrazine application.

I believe there are some crops in the Midwest which will never be economically viable under an organic approach, but for which IPM strategies can be very workable. An IPM producer has two options: simply market the product as a conventional product, or market it as an "improved" or "environmentally friendlier" variation of a conventional product. One example of the latter strategy would be for a PYO strawberry grower to assertively tell customers that "Yes, we use pesticides but these are the things we do to make sure we only use them when we absolutely have to." Such an approach is easiest for direct marketers (PYO's, farmers marketers, etc.) because these producers communicate directly with their customers on a daily basis.

The Dutch recognized the growing interest in environmentally friendly production when "production method" was added to the description criteria for Dutch fruit and vegetable auctions.

A system called MBT(an abbreviation for a Dutch phrase meaning "environmentally conscious cultivation"), has been introduced over the past few years for a limited number of crops. Currently 80% of the greenhouse tomato, cucumber and sweet pepper crops are now produced without use of pesticides. Producers use cultural or biological controls for pest problems; the system differs from organic systems because producers can use synthetic fertilizers. Growers identify their products by the simple addition of a butterfly symbol to product packaging. Standards are enforced within the industry to assure compliance, but aside from education within the trade, there has been minimal consumer promotion. But the grower popularity of the system is increasing; soon leeks, lettuce, mushroom and eggplant will be added. Standards for existing crops will be further tightened to encourage fertilizer system recycling and reduced energy consumption.

A recently initiated project in Massachusetts has created a "Partners with Nature" logo that can be used by approved IPM practitioners. Program standards for sweet corn, strawberries, and apples have been developed. Consumer attitudes and willingness to buy are being tested. Consumer education and awareness is a long term goal of the project.

Low/No Residue, "Natural" Meats: The area of meat marketing is complex because of meat labeling history and jurisdiction. The USDA has authority to approve or disapprove all meat labels. Until very recently there has been no great demand for labels concerning production practices such as use of animal growth hormones, sub-therapeutic use of antibiotics, or issues of animal welfare. The science of production is also complex; many (most?) consumers don't stop to think that "hormones" are naturally produced by living creatures, and that use of such "chemicals" may not add any new ingredient to a meat product that isn't already there. Nonetheless, the communications between producers and consumers is muddied, and few helpful systems of standardized terminology exist to clarify the issue.

This is changing slowly. The USDA has already approved labels referencing producer conformance to the "USDA's Residue Avoidance Program," a production system which is to monitor and reduce (ideally eliminate) the existence of non-naturally produced chemical residues. Use of this program may be one means for livestock producers to legally identify their products in the marketplace.

sustainable manner). The report identified existing, unfilled demand for products to be used for dried decorative arrangements, primarily for export for Europe. Can Minnesota producers fill this existing demand?

Direct Marketing: Selling products directly to consumers can be a viable option for producers of all kinds of products. Especially for the producer using IPM practices, this may be a first step since it does not require a wholesale and retail infrastructure to be in place to explain the products to the consumer. Instead, the producer has the opportunity to do that every time a potential consumer is encountered. There are many forms of direct marketing: PYO farms, farmers markets, roadside stands, etc. The Minnesota Department of Agriculture has educational material available and co-sponsors educational seminars on direct marketing. A relatively new form of direct marketing is called Community Supported Agriculture (CSA). In this system, also sometimes known as subscription farming, a group of consumers contract with a producer to supply certain products. The contract specifies quantity and quality of products, time frame, delivery schedule, prices and contingencies. The Minnesota Food Association has been assisting in connecting interested farmers and consumers. They can be reached at (612) 644-2038.

Organizing to Capture Added Value

As already noted, 76% of the retail product value goes to the non-producer portion of the marketing chain. It is also this portion of the marketing chain which has the greatest ability to capture the value added due to processing, product branding, etc. If producers are to capture any portion of this added-value, they must participate in this part of the market. To do this, in my opinion, will require a re-shaping of the ownership of the value-added processing and marketing chain. This is most likely to happen through a new generation of producer-owned processing and marketing cooperatives.

The producer-owned cooperative has a strong tradition in Minnesota, and has served many producers well. As much today as any time in the past, producers must begin shaping their own destinies in the marketplace, rather than only riding the waves of commodity pricing. To do this certainly entails risk, and should not be viewed lightly. But in business, return is a function of risk: no risk, no reward.

In assessing how to develop new markets for sustainable products, one very quickly realizes that no single producer can fully develop and exploit a sizeable niche by himself/herself. The variables of supply consistency and continuity, as well as the incredible energy required to launch a new effort, all argue for collective action by like-minded individuals. The grower-owned cooperative is perhaps the best (though certainly not the only) business structure to reward a producer by providing an outlet for product as well as allowing the individual producer to share (through patronage dividends) in the added value derived from processing and marketing.

Producers who wish to develop new markets for sustainable agricultural products and who wish to benefit in the long term on a recurring basis, must give serious thought to organizing themselves and the marketplace so as to allow these goals to be achieved.

Summary

To become a permanent part of the agricultural landscape, individuals must go beyond sustainable production, and be marketers of sustainable products as well. Significant consumer education efforts are needed, and sustainable producers must re-cast the images of their products if they are to make inroads in the mainstream marketplace. Potential markets for products do exist, but these opportunities are largely undeveloped at this time. To benefit not just as producers of commodities but as participants in value-added processing and marketing, producers should give serious thought to creating producer-owned marketing cooperatives as tools for developing these opportunities.

Kevin Edberg has worked at MDA since 1987 and oversees the market development of fruits and vegetables, specialty crops, organic products and international trade. Before working for MDA, he managed a 120-acre fruit and vegetable operation near Forest Lake, MN for 10 years. He received his B.S. in Horticulture and Agricultural Economics, and in Secondary Education from the Univ. of Minnesota. He lives in White Bear Lake, where he coaches and judges the high school debate team, and is serving his 10th year on the White Bear Lake School Board.

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Project Title:	**Red Deer Farming as an Alternative Income - a Practical Application**	*Time Span:*	February 92 to February 94
Principal Investigator: *Address*	Peter Bingham RR 1, Box 262 Randall, MN 56475	*Tel:* *County:*	612-749-2197 Morrison
Cooperators:	David Stish - Farm Business Management Instructor Dr. R. M. Jordan - Animal nutrition, Univ. of Minnesota Dr. Cindy Wolf, D.V.M. - Vet. Med., University of Minnesota	*Enterprice*	Red deer

Project Description

Red deer farming may be a viable alternative to farmers who want to diversity their operations. Consumers who enjoy venison, or lean, low cholesterol red meat would provide a ready market for this enterprise. Per capita venison consumption in the United States is currently less that one pound per year. However, 85% of venison is imported from New Zealand.

New Zealand deer farm methods will be demonstrated along with a rotational grazing system, deer handling equipment and fencing. Direct marketing or pooling of meat production for a specialty market will also be investigated.

Project Results

Twenty-nine red deer were rotated during the summer months and fed supplements. Because of the drought, forage was in limited supply and alfalfa hay and supplements were purchased to replace feed expected from pasture. An additional pasture was set up to increase the number of paddocks to four. Under good, productive pasture conditions, three hind-fawn units are the equivalent of one cow-calf unit.

Observations

Initial costs of deer farming are high. Once the operation is underway, the inputs are very low in terms of energy , shelter, supplemental feeds and labor. There are no fossil fuels used for day-to-day feeding other that initial feed purchases and pasture preparation. No herbicides or insecticides have been used.

Gross Margin Analysis for Red Deer 1992

Number of Acres in IRG Pasture	11
Total Number of Deer Grazing	29
Gross Profit	$8242.54
Gross Profit / Acre	$749.32
Total Variable Costs	$4220.92
Purchased Feed	$2128.57
Livestock Costs	$279.60
Pasture Costs	$841.48
Operating Costs	$971.27
Variable Costs / Acre	$383.72
Gross Margin/Acre	$365.60
(Gross profit/acre - Variable cost/acre)	

Labor inputs are minimal and farmed red deer are simple to manage. Red deer adapt well to Minnesota's climate. They are efficient users of forages, thriving on native grasses as well as on improved pastures. Males weigh between 400 and 500 pounds and the females weigh about 210 pounds. Females have a 15 year productive life span. They group together or herd which makes them ideal to handle on a farm. A defined breeding season and predictable calving times reduce labor inputs as well.

Agriculture needs to diversify so that farmers can have economic stability and red deer offer new opportunities to full and part-time farmers, both on large and small acreages to diversify.

Location of Project

North bound on Hwy 10, 8 miles north of Little Falls, go northeast on County Road 209; 1.5 miles to intersection of County Road 208 and 210. House located on northeast corner, gray with white trim.

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Project Title:	**Cutter Bee Propogation Under Humid Conditions**	*Time Span:*	March 92 to October 93
Principal Investigator: *Address*	Theodore L. Rolling Box 109B Ivanhoe, MN 56142	*Tel:* *County:*	507-694-1483 Lincoln
		Enter-prise	Cutter Bees, alfalfa

Project Description

Cutter bees are known as excellent pollinators of alfalfa in the western United States and western Canada. Not much is known about how they would do in the humid conditions in Minnesota.

This project focuses on raising and propogating cutter bees under the humid conditions here in the Midwest with the goal of producing alfalfa seed. If this is successful, there are possibilities of establishing a market for cutter bees to alfalfa farmers in other states.

Project Results for 1992

The cool summer of 1992 prevented optimal propogation of the cutter bees. Cutter bees are most active in temperatures above 85°F. In 1992 there were only 2 days between May 26 and July 31 in which the temperature was 85°F or above.

The bees were released during sunny days at high ambient temperatures (90°F). About 10% of the bees were in the flight stage with the rest actively hatching. The first night became rainy and the temperature dropped into the 50's. The bees that were flying and able to feed survived and reproduced, while the unhatched bees succumbed to cold weather.

The days that followed remained cool. The bees are not mobile at temperatures below 70°F, and became easy prey for robins and other birds. This really hurt the population of the bees.

Later in the season, the continued cool weather caused late blooming of the alfalfa. This forced Rolling to shut down bee incubation to delay hatching. When hatching was resumed the weather stayed cold for the next two weeks and resulted in poor emergence.

Two samples were taken and examined. The results are as followed:

	Sample #1	Sample #2
Weight of sample	15.95gm	21.42gm
No. of cells in sample	179	223
Live larvae	89.4%	88.0%
Pollen balls	7.8%	7.6%
Second generation	2.2%	1.3%
Moldy	0.6%	1.8%
Dead	0.0%	1.3%
Parasites	0.0%	0.0%
Chalkbrood	0.0%	0.0%
Live larvae /pound	4551	4149

Despite cool weather the bees persisted and propogated all summer. Tests showed high quality bees. No trace of parasitism or disease was found; the number of pollen balls was very low; and moldy and dead larvae were insignificant. Live larvae per pound was high and proves that cutter bees can successfully be raised in this area.

The poor weather and low bee activity reduced alfalfa seed production. Rolling extended the main flowering period of the alfalfa by clipping strips. As these clipped strips were starting to bloom the unclipped strips were finished blooming. This provided a continuous food supply for the bees.

Management Tips

1. There must be adequate incubation facilities with shut down capabilities. This would allow the operator to stagger bee release to take advantage of favorable weather and avoid a large loss during untimely poor weather.

2. Spread the shelters around in the alfalfa field so that the bees do not have to fly too far for food.

3. Put screen shelters around the nests so the birds don't get to the bees as they are warming up in the sun.

Location of Project

Three miles east, one mile north and 1/2 mile west of Ivanhoe.

livestock wastes may also create contamination problems. Increasingly, reduced tillage systems are becoming thought of as sustainable practices. Many observers feel that such rotation/tillage production systems have a number of other benefits in addition to reduced fertilizer and pesticide purchases. This second approach is assumed in this article in which one or various cropping and tillage systems are potentially sustainable and the issue is how these alternative systems compare economically among themselves and with conventional systems.

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Clearly, the overall returns and costs for the entire system need to be considered not simply one part of it.

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Early in the history of sustainable agriculture the impact of sustainable agricultural practices on simply crop yields was stressed. The question was can crop yields of a principal crop be maintained using long-term rotations and livestock waste reducing fertilizer and other chemical expenditures? If such were true, it might be supposed that farmers might accept such systems. The problem is that this approach overlooks the returns on those acres not in the principal crop. Clearly, the overall returns and costs for the entire system need to be considered not simply one part of it.

The economics of sustainable agricultural systems first considers how different systems compare in dollar terms for the individual farmer. Generally speaking, higher profit systems are those used by farmers. However, we need to explore why the highest profit systems may not always be selected by a farm business. First, dollar returns are only one objective that farmers consider in their decisions. Convenience, risk, and a host of other factors are considered by farmers. In addition, with respect to sustainable agriculture, issues such as soil character, long-term soil condition, erosion, and various previously mentioned issues appear to be important. Particularly when one production system is only marginally better than others in dollar returns, these broader considerations may outweigh dollar returns. Clearly, we know that farmers differ considerably in their value structure. Economists sometimes attempt to attach dollar values to these various objectives. One objective for which this has been somewhat successful is risk which we will not examine here.

The term "profits" and "net returns" also need explanation. The term profitability is often used loosely but strictly speaking it refers to dollar returns after removing all costs of production. The term "net returns" stops short of this by removing only part of the costs of a system. For example, subtracting operating costs from gross receipts results in a net return to land, operator labor, investment capital, and management. In this case, costs would not include any interest costs or rental payments on land and investment capital. Going further, other costs could be subtracted. Usually, analysts remove only those costs for which there are differences among systems. For example, among cropping systems, land costs are the same regardless of system, and removing or not removing those costs does not affect the relative economic ranking of systems.

Suppose we want to compare various systems economically. A system would refer to a particular rotation and set of farming practices. Often the crop yield data come from experimental or actual farm data ordinarily, the gross return (yield times price) is relatively easy to estimate. As we previously said, we have a range of choices of what costs to include but we might consider two here. The first is to include only the operating costs for each system without considering investment differences among systems. This is termed short run and assumes a farmer has an existing machinery set which can be used for alternative crop systems. For example, in 1986 we compared returns over operating costs for three eastern Nebraska rotation systems 1) conventionally produced continuous corn, b) conventionally produced corn-soybeans, and c) corn-soybeans-corn-oats/sweetclover with no purchased fertilizer or herbicides. Net returns to land, overhead labor, investment capital, and management were estimated at $73.64, $175.15, and $114.88 per acre respectively. In that study, overhead labor was separated from direct field operation labor and the latter subtracted from returns. We are presently revising and updating this analysis.

Another perspective of the economics of these systems is to fully cost all of the resources required for each system for resources which are different between systems. Thus, if the machinery ownership costs for continuous corn are different from that for the other two, such differences are important to the long-run economic assessment of each system. While this is more difficult than

Soil Fertility

Liquid Surface Manure Application in Ridge-Till System: Fall vs. Spring Applied

A liquid mixture of hog and chicken manure will be applied in the spring and in the fall on ridge-till continuous corn crops and on corn-soybean fields. Crop yields from the manure fertilizer treatment will be compared to commercial fertilizer treatment applied at equivalent rates. This project will provide information on optimum season to apply manure on a ridge-till system so that petroleum-derived commercial fertilizers can be reduced.

Principle Investigator	Phone
Dwight Ault	(507) 437-3085
Route 1, Box 230	**County**
Austin, MN 55912	Mower

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Tillage/Residue Management Demonstrations

This demonstration will compare the crop yields and economics of using different tillage systems (minimum till, ridge till, and no till) as well as different fertilizer sources (such as gypsum, soft rock phosphate, and micronutrients) and the use of cover crops in corn and soybean cropping systems.

Principle Investigator	Phone
Gary Wyatt	(507) 375-3341
Watonwan County Extension Service	**County**
St. James, MN 56081	Watonwan

Intensive Rotational Grazing

Grazing Limits: Season Length and Productivity

Approximately 50 acres of conventionally-farmed land will be converted into a sustainable rotational grazing system for beef production. Over a period of three years, the Balows will demonstrate seeding and establishment of forages, managing beef cows on pasture, and use of a solar watering system to provide cows with water while on pasture. This profitable farming system requires almost no petroleum-based commercial fertilizers, herbicide, insecticides, and drastically reduces fuel usage.

Principle Investigator	Phone
Doug and Ann Balow	(612) 923-4279
RR 3, Box 123	**County**
Goodhue, MN 55023	Goodhue

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Speciality Crops

Demonstrations of Cover Crops and Mulch used in Organic Farming

The Vosejpkas will show how cover crops and mulch can be used to reduce weed pressure, hand-weeding requirements, and increase soil fertility and yields in an organic produce/flower operation.

Principle Investigator
Gary and Maureen Vosejpka
118985 Cabot Avenue
Dundas, MN 55019

Phone
(507) 645-4182
County
Rice

Cropping Systems

Living Mulches in West Central Minnesota Wheat Production

Four different legumes will be interseeded with spring wheat to provide nitrogen, to smother weeds, and to provide soil cover throughout the winter. The objectives are to reduce the costs of producing wheat, the use of commercial fertilizers and herbicides, and the incidence of soil erosion.

Principle Investigator
Dave Birong
35805 - 535th Avenue
Grove City, MN 56243

Phone
(612) 488-4552
County
Meeker

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Making the Transition to Certified Organic Production

In 1993-95 Murphy will manage the transition of 195 acres to meet or exceed organic certification standards. The transition will be evaluated and documented to show the profitability of this process, as well as production details, such as: yields, weed management, soil condition, etc. This project also involves the use of a reduced tillage system that is not dependent on chemical weed control.

Principle Investigator
Craig Murphy
Route 3, Box 111
Morris, MN 56267

Phone
(612) 392-5176
County
Stevens

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Intensive Rotational Grazing

Using Sheep and Goats for Brush Control in a Pasture

One obstacle to converting woodland into pasture is the emergence of brush, or browse species. Sheep and goats were used in this study as biological controls for suppressing woody brush growth as alternatives to herbicides. The pasture was set up in an intensive rotational grazing system for raising sheep and angora goats.

Principal Investigator	Time Span	County
Alan and Janice Ringer 1765 Pequaywan Lake Road Brimson, MN 55602 218/848-2475	April 89 to November 91	St. Louis

*****

Intensive Rotational Grazing in Sheep Production

Switching to an intensive rotational grazing system from a conventional cool-season low-intensity grazing system requires an investment in time and capital and new management skills. Environmental benefits, energy and production cost savings, as well as livestock production levels were demonstrated in this project.

Principal Investigator	Time Span	County
James M. Robertson Route 3, Box 182 Wadena, MN 56482 218/631-4618	April 89 to December 91	Wadena

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A Demonstration of an Intensive Rotational Grazing System for Dairy Cattle

A year-round stored feeding system for dairy production was changed to an intensive rotational grazing system. This demonstration focused on paddock arrangements, latest fencing technology, and on frost seeding - a low cost method of pasture renovation. This system greatly reduced feed costs, electricity and fuel usage.

Principal Investigator	Time Span	County
Ken Tschumper Route 1, Box 194 LaCrescent, MN 55947 507/894-4248	April 89 to November 91	Houston

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Demonstration of Tillage Effects on Utilization of Dairy and Hog Manure in Southeastern Minnesota

Farmers commonly fertilize soils with animal manures without knowing the rates of application of nitrogen concentration. 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 and soil erosion. This project examined a series of strategies for reducing over-application of manure and commercial nitrogen.

Principal Investigator	Time Span	County
John Moncrief Soil Science Department University of Minnesota St. Paul, MN 55108 612/625-2771	April 89 to January 91	Goodhue

*****

Improving Groundwater Quality and Agricultural Profitability in East Central Minnesota

The Chisago/Isanti County cluster is located in the Anoka Sand Plain area, one of the two major regions in Minnesota where nitrates in groundwater are a major concern. This study evaluated the Hach field nitrate testing kit to help farmers do "on-the-spot" analysis of nitrogen needs to minimize excessive inputs.

Principal Investigator	Time Span	County
Steven Grosland and Kathy Zeman 221 SW 2nd Ave. Cambridge, MN 55008 612/689-1810	April 89 to November 91	Chisago

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Demonstration of Land Stewardship Techniques in the Red River Valley

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. Sugar beets, pinto beans and wheat were evaluated under conventional and reduced input systems.

Principal Investigator	Time Span	County
Donald H. Ogaard 11 East 5th Avenue Ada, MN 56510 218/784-4156	April 89 to January 92	Norman

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Soil Building and Maintenance

Alternatives to chemical fertilizers and herbicides include the use of raw manures, compost and legumes for maintaining soil fertility, and rotary hoeing for weed management. Two legume systems and two livestock manure systems were compared for their effects on soil fertility, weed management, environmental benefits, yields and cost effectiveness. The project also looked at the cost benefit of using alfalfa as a cash crop compared to row crop corn/soybean system.

Principal Investigator	**Time Span**	**County**
Larry H. Olson Route 1, Box 136 Granite Falls, MN 56241 612/564-2571	January 89 to December 91	Yellow Medicine

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Specialty Crops

Mechanical Mulching of Tree Seedlings

The first three years after planting Christmas trees are critical in determining whether the tree seedlings will survive. Weeds are a major threat to young trees and are usually controlled with herbicides, which are often applied at rates exceeding those used on cropland. As an alternative to herbicides, vegetation surrounding the trees were chopped and used for mulching the tree seedlings.

Principal Investigator	**Time Span**	**County**
Timothy and Susan Gossman Route 1, Box 110A Chatfield, MN 55923 507/867-3129	April 89 to October 91	Fillmore

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Benefits of Crop Rotation in Reducing Chemical Inputs and Increasing Profits in Wild Rice Production

Continuous cropping of wild rice with the use of fungicides and herbicides to control disease and broadleaf weeds is practiced by most wild rice producers. Rotating wild rice with other crops has the potential to lessen the demand for chemicals. This study compared continuous wild rice cropping with a rotational system of wild rice, alfalfa, canola or fallow.

Principal Investigator	**Time Span**	**County**
George Shetka Fleming Road, Box 6402 Aitkin, MN 56431 218/927-6617	August 89 to August 91	Aitkin

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Benefits of Weeder Geese and Composted Manures in Commercial Strawberry Production

Geese can fit 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 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 explored the use of geese for weeding strawberries and also evaluated composted manure blends for fertility.

Principal Investigator	Time Span	County
Joan Weyandt-Fulton 3780 Sandberg Road Duluth, MN 55810 218/624-3971	April 89 to November 91	St. Louis

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Minnesota Integrated Pest Management Apple Project

Apple production is the leading fruit production industry in Minnesota. Apple scab (*Venturia inaequalis*) is the most serious fungal disease affecting apples. Conventional control of this disease involves numerous sprayings of fungicide throughout the season on a calendar basis. This project demonstrated the use of scouting and monitoring for the pest in order to reduce fungicide application.

Principal Investigator	Time Span	County
John Jacobson Pine Tree Apple Orchard 450 Apple Orchard Road White Bear Lake, MN 55110 612/429-8026	January 89 to December 91	Dakota

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variation and increase the ability to distinguish among treatments for the trait under study. The researcher often includes a wide range of treatments, eg. different hybrids or chemical herbicides for weed control, including some sub-optimal treatments for comparison or for academic interest. Researchers have often been concerned about the lack of rigor in on-farm comparisons.

These two approaches may both be right! Depending on the objectives, the types of differences we want to observe or measure, and the relevance of the results to a specific farm or area it may be appropriate to use one or the other of these "research methods." For example, to test the value of a new planter a farmer may plant half of a field with the old planter and then switch to the new. If the field is fairly uniform and all other practices are done uniformly across the area, there should be no difficulty in comparing ease of operation, distribution of seed in the furrow, emergence of the crop, amount of residue left on the surface, and success of weed control within the row. These are qualitative differences, can be observed between the two halves of the field, and are important primarily during crop establishment. On the other hand, small plots may be most appropriate when it is important to compare a large number of promising new hybrids, when the potential differences among them are small, and when previous weed populations, nutrient status, and moisture accumulated may be variable within the field. This is when replicated plots that are carefully observed through the entire season can be most valuable. In either case, the research is part of an educational process for farmer and for researcher.

Where do we locate research areas?

Farmers and researchers may have different ideas about where to locate trials, both in choosing which farms and where on the farm to place comparisons. This depends again on the objectives and on convenience. For example, farmers may want to have trials:

- located on representative soil type for that field or that farm
- convenient for planting, application of treatments, observations and harvest
- where location does not interrupt other enterprises or practices on the farm
- visible to visitors, if demonstration is an objective

In contrast, a research or extension specialist may have different objectives for the specific research activity, and want to have trials:

- convenient to university or country extension office
- visible on a blacktop road for demonstration or for field days
- located on a soil type not found on the experiment station
- geographically located where grant funds specify the activity should take place

For cooperative on-farm research to be successful, it needs to meet the objectives of both groups to the greatest extent possible. There are many kinds of comparisons that are of greatest interest to one group or the other, and it is most appropriate that these not be included in a cooperative, on-farm research agenda. Partly, this decision is based on whether we are interested in our own education (as a farmer, what will work for me?), or in developing some broader principles (as a researcher, how can I develop recommendations that will be useful in a larger area?). In either case, it's important to carefully spell out the objectives and design an activity that will be appropriate to meeting those objectives.

Setting up an experimental design

We've already looked at examples of where a field could be divided in half to test a new piece of equipment, and where a large number o hybrids are to be compared to detect small differences in yield. These are the extremes in design, from a large demonstration field to small, replicated field plots of different hybrids. There is type of design that has been used with great success to meet the objectives or both farmers and researchers: The "side-by-side strip test." Recently made popular by the Practical Farmers of Iowa, this approach is similar to that used on thousands of locations by hybrid seed corn companies. Two examples of this type of experiment are:

- hybrid strip tests with each plot one planter widths by the field length, allowing change of seed at the end of the field; an alternative is one complete round with each hybrid or variety, so that all seed can be kept on a wagon or pickup at one end of the field.
- strip tests of starter or other fertilizer levels (or none) that are the width of the applicator by the field length, allowing adjustment or calibration of the equipment at the end of each

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On-Farm Research and Demonstration Program

While most agricultural field experiments are conducted on experiment stations, or university -owned research farms, "on-farm research" is conducted by researchers on commercially-operated farms in cooperation with the producers.

Pros and Cons

On-farm research tests practices or treatments under actual farm conditions using standard farm machinery. Researchers rely on producers to manage the field work. The results are more relevant and believable to the farmers who have participated on the project, and to other farmers who have observed the demonstration. A disadvantage to this method is that environmental variable (such as fertility, weeds) which may impact the results cannot be controlled as on experiment stations or in greenhouses. In some cases, it may be difficult to interpret results and determine the exact nature of the treatments, due to the influence of outside variables, or "experimental error."

Despite these drawbacks, on-farm research is a useful tool for farmers and researchers to develop alternative farming methods. The key to successful on-farm research is farmer/researcher cooperation. The farmers come up with research questions - based on what type of information they feel they need - and the researchers develop strategies to study the questions.

Research Strategies

The studies are conducted on farmers' fields, on long, narrow plots (from 125 to 1320 ft), wide enough for one or two passes of farm equipment. The number of treatments per experiment may vary (e.g. anhydrous ammonia vs. 28% nitrogen; moldboard vs. chisel plow turndown of alfalfa). To allow for statistical analyses, the treatments are applied in side-by-side random blocks then replicated two to three time.

Progress Update

The Energy and Sustainable Agriculture Program started doing on-farm research projects in 1988. The major effort early on was a weed management study carried out on 4 corn-soybean farms from 1988 to 1991 in south-central Minnesota. The farmers compared rotary hoeing to herbicide in terms of economics and yields in corn and soybean. They found that soybean yields were virtually the same under rotary hoeing and herbicide treatments, but that net returns per acre were almost $15/acre higher under rotary hoe treatment. Corn yields were lower by 4.5 bu/acre under rotary hoeing compared to herbicide weed control, and net returns per acre were $3.20/acre less under rotary hoeing treatment. Overall, rotary hoeing compared favorably with herbicide weed control. (For more details on this study, contact ESAP office.)

ESAP staff also initiated studies in compost management, conversion to organic farming, cover crops, and the use of legumes to provide nitrogen for grain crops.

The 1992 growing season was a challenge to researchers as well as to farmers because of below average summer temperatures. The vagaries of weather underline the importance of evaluating practices under the rigors of working farms and assessing several year's field data before drawing conclusions. This season's on-farm research effort focused on

Alfalfa Nitrogen Credits Based on Tillage Practice to Turndown Alfalfa Stand

Legumes such as alfalfa are beneficial to soil quality as well as good sources of farm-produced nitrogen. This study evaluated nitrogen credits from alfalfa to a following corn crop. There appeared to be more nitrogen available from the first year alfalfa crop to the following corn crop when spring tilled alfalfa was moldboard plowed compared to chisel plowed. Corn yields were statistically higher when alfalfa was moldboard plowed. While sidedressed anhydrous ammonia produced a slight yield increase over alfalfa nitrogen alone, legumes provided substantial nitrogen the first year to produce satisfactory corn yields.

Interaction of Turkey Manure with Fall Seeded Rye

Livestock producers normally apply manure in the fall after crop harvest. Because of this timing of application, there are nutrients available from the manure that are not being used, and presumably poses a leaching or run-off problem. Fall-seeded cover crops such as rye can serve as a reservoir to hold nutrients in place until the following crop has been planted. Once the rye has been killed, either through tillage or herbicide, there will be nutrients available for the next crop. In addition, rye has allelopathic qualities which reduce weed pressure.

Fall-seeded rye killed in the spring with herbicide with no additional herbicide application provided weed control comparable to conventional herbicide practices and to rye tilled in the spring followed by herbicide based weed control. There were no significant differences in weed counts or corn yields among the different management strategies.

Varying Nitrogen Starter Rates to Improve Nitrogen Management in Potato

Potato growers typically apply large amounts of nitrogen as starter fertilizer before the crop is ready to use the nutrients, which results in leaching problems. If fertilizer were to be applied at the hilling stage of potato development, when the nitrogen is needed, there would presumably be more efficient uptake of nutrients and less leaching.

In order to cut back on starter fertilizer rates, it is important to determine how much N is needed. The petiole sap nitrogen test could be a useful indicator of plant nitrogen status and therefore a useful tool for growers to manage nitrogen based on plant need. Using the test to determine at-hilling sidedress rates would result in more efficient nitrogen management in potatoes that would maintain crop productivity and improve ground water quality.

Three nitrogen management strategies (grower traditional strategy compared with two reduced starter rate and early application rate strategies) were compared to evaluate the sap nitrate test. Lowering nitrogen starter rates and total nitrogen rates did not affect potato yield when compared to grower traditional rates as long as nitrogen is available at later stages of growth.

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Project Categories

The Loan Projects involve many different management strategies. The types of projects and number of loans involved are listed in the table.

Project Type	Number of Accounts
Energy savings	15
Livestock management	13
Conservation tillage	41
Weed management	18
Manure management	13
Chemical and fertilizer reduction	32
Total Loan Accounts	132

Impact of Program

The loans have given Minnesota farmers added incentive to make changes toward more efficient use of inputs while enhancing profitability and protecting the environment. A total of 132 farmers have borrowed $1.38 million from the Sustainable Agriculture Loan Program to purchase over $2 million in farm equipment and facilities. To date, there have been no defaults on the loans.

As loans are repaid and the funds redistributed approximately $160,000 will be available each year for new loans. When farmers implement innovative changes, their neighbors have an opportunity to observe and decide whether to adapt changes to their farming system. In this way the farmers are demonstrating new, innovative, and alternative ways of farming and are serving as to accelerate the rate of adoption of sustainable agriculture in Minnesota.

The success of the Loan Program in Minnesota has generated great interest in other states. Indiana, Kansas, Kentucky, New Jersey, New York, and Virginia, have been studying the concept of the loan program to determine whether it is appropriate for their region. ESAP staff have been invited to speak about this program at many conferences throughout the country.

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Dan French farms 325 acres with his wife, Muriel, and son, Jason. The Frenchs grow forage and corn. They formerly had a farrow-to-finish hog operation and presently maintain a 60-cow dairy herd. The Frenchs have been using an intensive rotational grazing system for the dairy cows for the past 4 years. They are experimenting with seasonal dairying to further reduce feed costs and increase profits.

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