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PROLOGUE

This is the third technical report of the Wisconsin Integrated Cropping Systems Trial (WICST). In last year's report we discussed, in some detail, the objectives of the project, the results of the uniformity year (1989) and the first three production years (1990, 1991 and 1992). In this report we discuss the results of the fourth year of field trials (1993). This is the first time we have had all the phases of the six rotations running concurrently, permitting us to begin to compare all the systems.

The project continues to benefit from farmer input, the institutional support of the College of Agriculture, the Wisconsin Extension Service, the Michael Fields Agricultural Institute, the Walworth County Board of Supervisors and the Kellogg Foundation. But most importantly, the project is gaining support from the agricultural community. Field days are well attended, additional faculty are setting up research plots at the Learning Centers, and a growing number of school children are coming to the sites for guided tours. In addition, results from the Learning Centers are beginning to appear in print (Appendix I). We are optimistic that we are beginning to fulfill our underlying objective of serving as a forum for the open discussion of what directions Wisconsin agriculture should take in the 21st Century.

Summer, 1994

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INTRODUCTION

In the fall of 1988 a group consisting of faculty from the College of Agriculture and Life Sciences, agents from the Wisconsin Extension Service, agronomists from the Michael Fields Agricultural Institute, and farmers came together to design the Wisconsin Integrated Cropping Systems Trial (WICST). The overall objective of the trial was to compare alternative production strategies with the performance criteria of productivity, profitability and environmental impact. Concomitant with this technical objective was the decision to develop the trial in a "Learning Center" environment where all the members of the community could learn about agroecology and production agriculture.

From these discussions evolved a plan to work at two locations in southern Wisconsin. The Lakeland Agricultural Complex (LAC) is situated on the Walworth County Farm about 45 minutes west of Milwaukee, and the Arlington Research Station (ARS) is a University of Wisconsin research farm about 30 minutes north of Madison (see Figure 1). At both sites a 60 acre area was set aside and in 1989 a uniformity trial was held in order to facilitate the subsequent blocking of the core rotation experiment. 1990 was the first production year of the project.

The selection of cropping systems provoked a great deal of discussion within the group. Ultimately a factorial array of rotations was selected. It was observed that within southern Wisconsin there were <u>two principal types of farm enterprises</u>; cash-grain and forage-based systems, each with its own production requirements. At the level of <u>production strategy</u>, the hypothesis developed was that as systems became more complex, they would require less and less external inputs to remain productive. As a result, production strategies with a high, medium and low level of complexity were designed. Put in an inverse fashion, systems that required a high, medium and low level of purchased inputs were put into practice. The six rotations are schematically represented in Figure 2. Some of the anticipated differences between the rotations are outlined in Table 1.

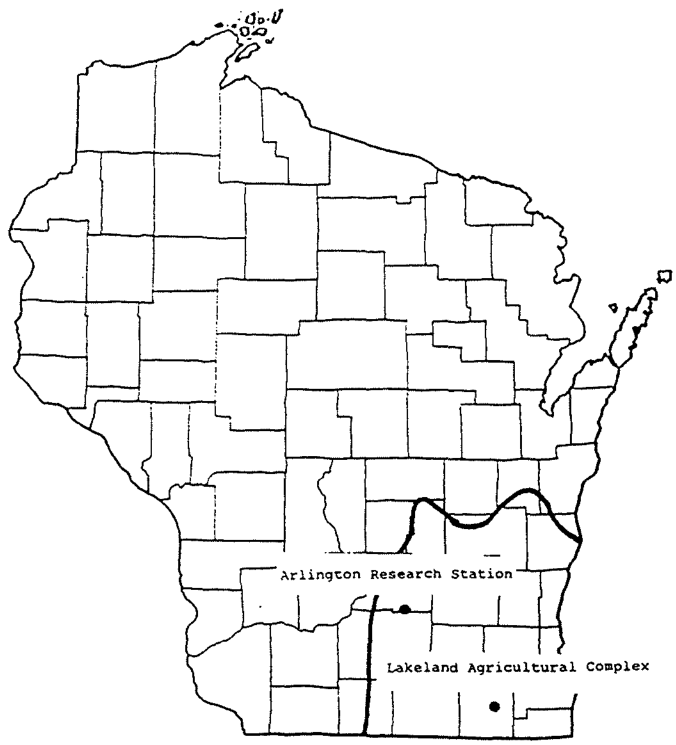

Figure 1. Outline of Major Land Resource Area 95B and Two Sites of the Wisconsin Integrated Cropping Systems Trial

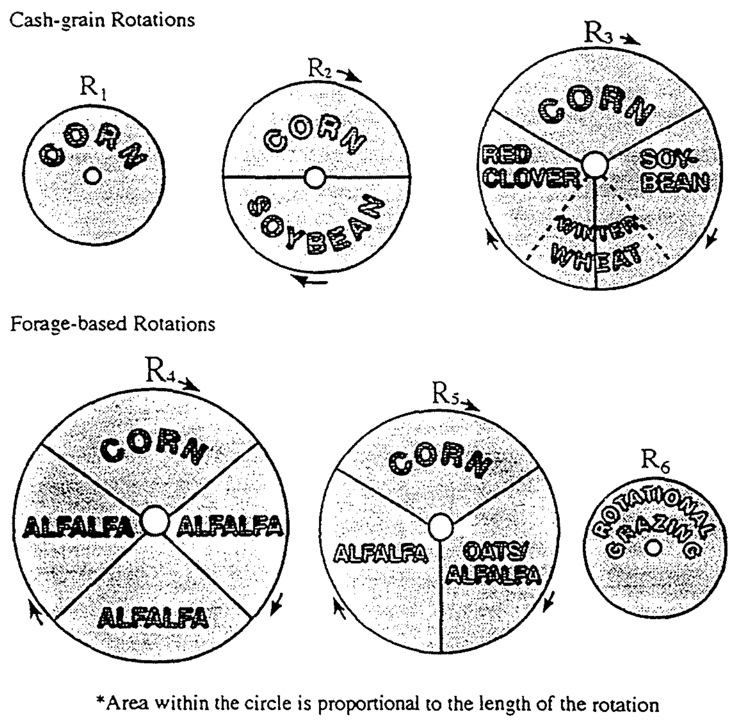

Figure 2. Schematic Drawing of the Rotations in the Wisconsin Integrated Cropping Systems Trial

I. YIELDS, WEATHER AND AGRONOMIC CALENDAR IN 1993

A. Wood*, P. Ehrhardt*, T. Mulder**, and J. Posner**

Crop production was difficult in 1993. Winterkill, although not as severe as in 1992, affected 20% of the winter wheat crop and 25% of the alfalfa stands statewide (Wisconsin Crop Weather, Dec 7, 1993). Estimates made in late April indicated that winter wheat stands at the Lakeland Agricultural Complex (LAC) and the Arlington Research Station (ARS) were 50% of optimum, and alfalfa stands were 10-40% of optimum. Heavy April rains (see Table 2) delayed first plantings, and cool May temperatures (Growing Degree Days units only 70% of the long term average (Figure 3.) delayed emergence, increasing weed pressure. Corn and wheat yields were poor in 1993, soybean yields variable, and forage yields a bit below average (See Table 2). A quick review by crop follows:

I. Corn Phases:

Initially it was envisioned that Pioneer 3417 (RM 109d) would be used in R1, R2 and R4 corn planted prior to May 5th and Pioneer 3563 (RM 103d) with later planted R3 and R5 corn. All corn treatments were to planted at 32,000 seeds/A. Due to wet, cool soils at LAC, P3563 was used in all 5 treatments and planted on May 13th. On the better drained ARS soils the first plantings were on May 1st and the later plantings on May 13th. Starter fertilizer and nitrogen additions followed the original protocol. Weeds were chemically managed in R1, R2, and R4 corn with a pre-emergence application of Dual and a post-emergence application of Buctril at ARS and with pre-emergence Extrazine + Confidence and post-emergence Buctril at LAC. At both sites, special weed problems are developing: 1) the no-till R2 corn continues to have perennial weed problems (thistles) at ARS and the continuous R1 corn at LAC is experiencing increasing lambsquater pressure. Mechanical weed control in R3 corn at LAC was accomplished with two rotary hoeings and three cultivations while the corn following alfalfa (R5) received only two passes with each the rotary hoe and cultivator. At ARS, the rotary hoe was used three times on each treatment followed by two cultivations. At both sites, mechanical weed control in corn was mediocre.

II. Soybean Phases:

Pioneer 9272 (Maturity Class 2.7) was used at both sites for the R2 drilled beans and planted on May 13th. On the same date, the R3 row beans were planted with shorter cycle Kaltenberg 241 (Maturity Class 2.4) since wheat was going to be sequentially seeded on these plots. Chemical weed control in the R2 drilled beans consisted of the use of post emergence herbicides Pinnacle and Classic in addition to Poast at ARS and Assure at LAC. In the R3 row beans, mechanical weed control consisted of two rotary hoeings and three cultivations at ARS and three rotary hoeings and two cultivations at LAC. Poor weed control at LAC resulted in poor R3 soybean yields.

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* Superintendents of the Lakeland Agricultural Complex and Arlington Research Station respectively.
** Project manager and research coordinator of the Wisconsin Integrated Cropping Systems Trial.

III. Wheat/red clover Phase:

Wheat was flown on at both sites in September 1992. The red clover was frost seeded in early April, 1993. The ridge and furrow field surface (after cultivating the R3 soybeans) resulted in a streaky stand at both locations. Stands were sharply reduced in the old soybean furrows. At both sites, wheat tillered poorly and yields were low. This permitted very vigorous red clover growth. The cutter bar was set high for wheat grain harvest and then cut lower, picking up more straw and a great deal of red clover top growth. This material was taken off and used as forage for dry stock. In the fall, the plots were undercut with sweeps to facilitate corn seed bed preparation in the Spring of 1994.

IV. Forage Plots:

New seedings were put in on May 1 at ARS and May 20th at LAC. At ARS, two haylage cuts were taken from the R4 seeding and only oats for grain from the R5 seeding. At LAC, one cut of hay was made on the sole- seeded R4 plots and oatlage and one cut of hay was taken from the R5 plots. The wet spring resulted in a lot of alfalfa seedling death and three of the four R4 plots were no-till reseeded with alfalfa (16#/A) in the fall of 1993.

Reseeding took place in all the established hay plots. At ARS perennial ryegrass (Parana @ 5#/A), and red clover (Arlington @ 6#/A) were used on the second hay year plots of R5 and perennial ryegrass and alfalfa (Magnum @ 8#/A) on the first hay year plots of R4. Depending on the stand in R5 either perennial ryegrass (5#/A) plus red clover (6#/A) or just perennial ryegrass was used. These plots were all no till interseeded on April 28th. While the red clover and ryegrass additions did renovate the stand, reseeding with alfalfa, in only partially winter-killed stands, was not successful. Three haylage cuts were taken off all the established plots on June 11th, July 13th, and September 2nd.

At the Lakeland site, all the established hay plots were reseeded with medium red clover (12#/A) and annual ryegrass (3#/A) on May 8 with a no-till drill. The reseeding was successful and three cuts were taken off all the plots on June 12, July 13th and August 26th.

At both sites, the pastures (R6) were renovated with Arlington red clover in early April using a cyclone seeder on an ATV at LAC and by hand with a cyclone spreader at ARS. At LAC the rate was 20#/A and at ARS it was 12#/A. The reseeding was more successful at LAC than at ARS. The agronomic diary and commentary by the farm superintendent for the Arlington site are in Appendix II and for the Lakeland site in Appendix III.

Table 2. Growing season rainfall (inches) at the Wisconsin Integrated Cropping Systems Trial.

a. Arlington Research Station[1]

Month	1993	1992	1991	30-yr avg 1959-1988
April	7.06(+4.07)	3.96(+0.97)	4.52(+1.53)	2.99
May	4.52(+1.33)	1.22(-2.97)	1.91(-1.28)	3.19
June	6.10(+2.30)	1.19(-2.61)	2.63(-1.17)	3.80
July	9.40(+5.94)	5.80(+2.34)	3.75(+0.29)	3.46
August	3.20(-0.69)	1.91(-1.98)	1.78(-2.11)	3.89
September	4.20(-0.03)	7.46(+3.23)	4.70(+0.87)	4.23
Growing Season Total	34.48	21.54	19.29	21.21
Yearly Total	42.25	34.43	35.33	31.14

b. Lakeland Agricultural Complex

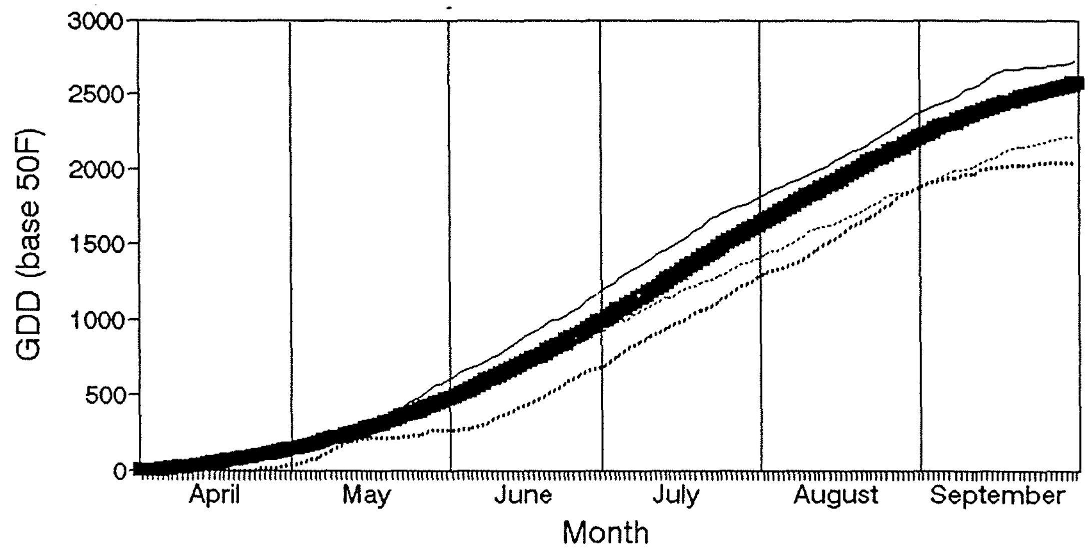
Month	1993[2]	1992[2]	1991[2]	30-yr avg 1959-1988[3]
April	5.55(+1.75)	2.21(-1.59)	4.15(+0.35)	3.80
May	1.90(-1.36)	0.50(-2.76)	2.32(-0.94)	3.26
June	8.50(+4.57)	1.35(-2.58)	1.56(-2.37)	3.93
July	4.35(+0.00)	7.18(+2.83)	2.45(-1.90)	4.35
August	2.80(-1.21)	2.60(-1.41)	2.04(-1.97)	4.01
September	3.59(-0.47)	4.43(+0.37)	4.94(+0.88)	4.06
Growing Season Total	26.69	18.27	17.46	23.41
Yearly Total[3]	34.10	31.58	38.66	37.53

[1]Data from Arlington National Weather Service Cooperative station.

[2]Data from Lakeland Ag. Complex Automated Weather Station.

[3]Data from Lake Geneva National Weather Service Cooperative station (7 miles southeast of the Lakeland Ag. Complex).

a. Arlington Agricultural Research Station



b. Lakeland Agricultural Complex

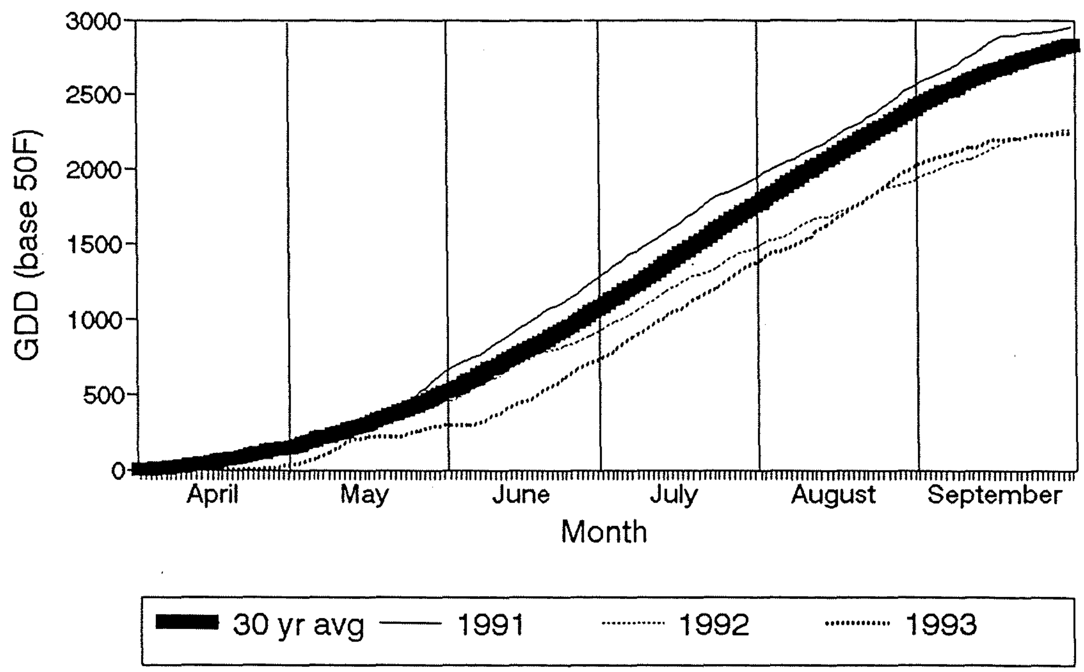


Figure 3. Cumulative corn growing degree days for the two WICST sites

Table 3. Yield Results for the Wisconsin Integrated Cropping Systems Trial (1990 - 1993).

a. Arlington Agricultural Research Station

Corn	1990	1991	1992	1993
	bu/A			
R_1 - Continuous corn	166.2	160.0	144.0	123.7[1]
R_2 - Corn after soybean	-	185.7	150.1	129.8
R_3 - Corn after red clover	-	-	99.2	87.1
R_4 - Corn after alfalfa	-	-	-	165.1
R_5 - Corn after alfalfa	-	-	112.0	119.1
LSD ($P<0.05$)	-	4.0	12.6	7.4

Soybean	1990	1991	1992	1993
	bu/A			
R_2 - Drilled soybean	56.5	58.5	30.1	52.8
R_3 - Row soybean	52.1	49.2	38.0	53.3
LSD ($P<0.05$)	NS	6.1	NS	NS

Wheat	1990	1991	1992	1993
	bu/A			
R_3 - Wheat	-	63.6	45.21	28.6

Seeded Alfalfa	1990	1991	1992	1993
	bu/A			
R_4 - Direct seeded	4.27	4.94	3.59	3.27
R_5 - Oats/alfalfa	3.93[2]	3.12[3]	2.63[2]	2.38[3]
LSD ($P<0.05$)	NS	0.36	0.49	0.51

Established Forage	1990	1991	1992	1993
	bu/A			
R_4 - Hay I	-	5.86	3.46	3.70
R_5 - Hay I	-	5.86	5.17	4.65
R_4 - Hay II	-	-	3.99	3.25
R_6 - Pasture	4.15	4.70	2.81	-[4]
LSD ($P<0.05$)	-	0.44	1.20	1.15

[1] Harvest moistures of corn were 29.2, 33.7, 33.7, 27.7, 29.9 % for rotations 1, 2, 3, 4, 5, respectively in 1993.

[2] Oats harvested as oatlage.

[3] Oats harvested as grain (grain and straw converted to T/A dm).

[4] IRG (Intensive rotational grazing of heifers) - 685 lb gain/A + .4 T/A hay. Animals supplemented with grain.

Table 3. (continued)
b. Lakeland Agricultural Complex

Corn	1990	1991	1992	1993
	bu/A			
R_1 - Continuous corn	165.5[1]	121.2	119.0	99.7
R_2 - Corn after soybean	-	144.7	126.2	101.2
R_3 - Corn after red clover	-	-	73.0	77.7
R_4 - Corn after alfalfa	-	-	-	113.3
R_5 - Corn after alfalfa	-	-	101.7	80.6
LSD ($P<0.05$)	-	13.1	16.9	22.2

Soybean	1990	1991	1992	1993
	bu/A			
R_2 - Drilled soybean	58.3	52.9	46.9	49.0
R_3 - Row soybean	51.3	54.5	51.9	32.3
LSD ($P<0.05$)	4.7	NS	NS	12.7

Wheat	1990	1991	1992	1993
	bu/A			
R_3 - Wheat	-	32.1	25.7	22.3

Seeded Alfalfa	1990	1991	1992	1993
	bu/A			
R_4 - Direct seeded	0	0.46	1.11	2.01[2]
R_5 - Oats/alfalfa	0.89[3]	2.47[4]	3.03[3]	1.67[4,5]
LSD ($P<0.05$)	0.55	0.63	1.02	NS

Established Forage	1990	1991	1992	1993
	bu/A			
R_4 - Hay I	-	3.88	3.65	2.87
R_5 - Hay I	-	3.49	3.54	3.37
R_4 - Hay II	-	-	3.57	2.61
R_6 - Pasture[6]	0	3.39	-[6]	-[6]
LSD ($P<0.05$)	-	NS	NS	NS

[1] Harvest moistures of corn were 26.3, 21.9, 26.4, 23.5, 25.3 at for rotations 1, 2, 3, 4, 5, respectively in 1993.
[2] Only one harvest, yield from 1 of 4 reps (3 reps ruined by rain and chopped onto field).
[3] Oats harvested as grain (grain and straw converted to T/A dm).
[4] Oats harvested as oatlage .
[5] Alfalfa is avg. yield from 3 of the 4 reps (1 rep ruined by rain and chopped onto field).
[6] IRG (Intensive rotational grazing of heifers) - 918 lb gain/A - 1992, 727 lb gain/A - 1993. Animals supplemented with grain in 1993.

II. SOIL HEALTH AND SOIL LIFE

A. Descriptive and Analytical Characterization of Soil Health and Quality for the Wisconsin Integrated Cropping Systems Trial

R. F. Harris, M. J. Garlynd, and D. E. Romig*

Introduction

Our Soil Health initiative was started in 1990 in response to farmer expression of a need for more research in the area of soil health and biology. The initiative coincided with increased scientific attention on methods to monitor and assess soil quality at the national and global level (Papendick and Parr, 1992). Investigations into the nature of soil health (term favored by farmers) and soil quality (term favored by scientists) identified that the development of a scorecard for characterizing soil health and quality should be a cooperative effort using the integrated knowledge of farmers and scientists (Harris et al. 1993; Harris and Bezdicek, 1994; Garlynd et al. 1994).

Our approach is summarized in Figure 4. Starting at the top of Figure 4, an exhaustive literature review complemented by interviews with Wisconsin and Washington State farmers lead to the development of a conceptual Interpretive Framework. This framework identifies different target systems, components, and categories of specific properties used by farmers and scientists to characterize soil health and quality, together with a related functional definition of soil health and quality. The left hand side of Figure 4 focuses on farmer knowledge of soil health. An Interview Guide provides a structured method for gathering information on how farmers recognize soil health. Application of the Interview Guide generates information needed to construct a farmer-based soil health scorecard that emphasizes descriptive properties of soil and non soil target systems, collated to provide a soil health score for a specific site. The right hand side of Figure 4 focuses on scientist knowledge of soil quality. Professional meetings, workshops and publications provide information on how scientists recognize soil quality. The emphasis of a scientist-based soil quality scorecard is on analytical properties of soil as the primary target system, and collation of these properties provides a soil quality score for a specific site. Finally, an integrated soil health and quality scorecard is envisaged as an ultimate goal. During development of the integrated scorecard, comparative analysis of descriptive soil health and analytical soil quality data should strengthen the refinement and applicability of both approaches. In particular, the availability of descriptive soil health data for a specific site provides an independent reference base for interpretation of the applicability and weighting of specific analytical soil properties as soil quality parameters.

The primary objective of our research is to measure the effects of different management systems on soil health and quality. We would expect certain management practices and aspects of particular crops to affect soil properties. According to Fraser et al. (1988) manure treated soils would develop a more porous friable surface layer resulting in a decreased bulk density and an increased pH due to elevated buffering capacity of the soil. Manure addition would provide food sources to microbial communities resulting in higher biological activity, enzyme activity being especially sensitive (Goyal et al. 1993). Manure also is useful in soil regeneration improving soil structure, soil hardness, organic matter levels and water transport (McHale, 1987). Tillage would tend to decrease water

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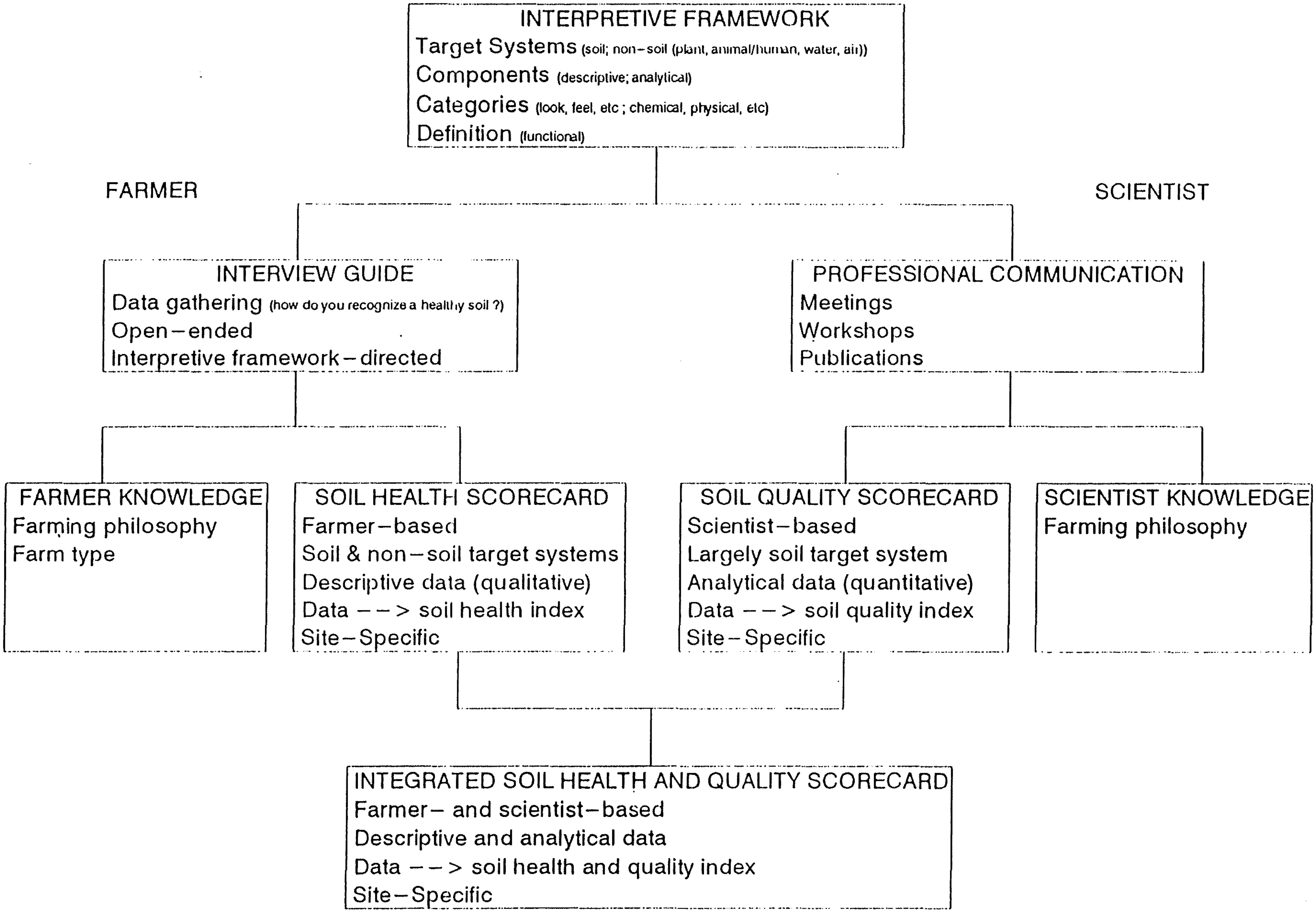

Figure 4. Assessment and monitoring of soil health and quality

stable aggregation and earthworm populations through mechanical disruption, and organic matter levels would decline from mixing with less concentrated soils and increased mineralization (Angers et al. 1993). Rotary hoeing would have a less severe effect on earthworm populations or macropore continuity down into the soil than other cultivation practices while no-till practices would preserve both the subsoil channels and burrows of macro-fauna. No-till practices would also be expected to show improved infiltration, soil surface crust and earthworm activity (Papendick, 1987). The level of synthetic inputs is one of the main differences between conventional (high input) and alternative (low-input) farming practices. The high input rotations would tend to exhibit increased nutrient levels due to carry over from the application of synthetic chemical fertilizers (Weil et al. 1993; Bolton et al. 1985). Elevated levels in physical properties like infiltration (Jordahl and Karlen, 1993) and water holding capacity (Logsdan et al. 1993) and biological properties like microbial biomass (Bolton et al. 1985) and organic carbon (Mallawatantri, 1992) are found in low-input compared to conventional-input fields. The increased microbial activity, specifically in the mycorrhizae could eventually lead to enhanced crop appearance (Lovel, 1989; Rateaver, 1989). Changes in physical and biological properties could be the result of management practices rather then differing chemical inputs. The longer rotations which include a small grain or hay crop would produce increased root growth near the soil surface stimulating microbial activity while actively growing and result in elevated levels of crop residue and organic carbon levels in the soil as they decay (Lynch and Bragg, 1985; Drury et al. 1991; Zien, 1987). Alfalfa would improve surface soil hardness and compaction from penetration of the sub-soil by tap roots. Cover crops are also associated with increased earthworm populations and trace mineral availability (Bender, 1989).

In this report we present the results of farmer interviews which were used to develop a farmer-based soil health scorecard We also summarize descriptive and analytical data of selected WICST sites for 1993 with continuous corn as a reference base.

WICST Farmer Interviews and Soil Health Scorecard

Materials and Methods

Farmers. Farmers were selected from the WICST's outside auditors group (Bacaltchuk and Powers, 1993). Between June 14 and August 1, 1993, Romig and Garlynd spoke with twenty-eight farmers, fourteen from both Columbia and Walworth counties. Each interview was conducted at the residence of the farmer and lasted approximately 45 minutes. In addition, farmers were asked to characterize their operation as to type, size, and management, and were categorized into "conventional", "low" and "no" synthetic chemical input groups (Table 4) based on their use of fertilizer, pesticide, and crop rotation practices (MacRea et al. 1990; Liebhart et al. 1989; Buttel and Gillespie, 1988).

Interview Procedure. The Interview Guide (within Figure 4) was designed to help guide the interview process, and to identify the nature and relative importance of properties that farmers use to diagnose and monitor soil health. Each farmer was asked the open-ended question, "How do you recognize a healthy soil?" Interviews were recorded and responses were coded to particular properties within the interpretive framework on the interview guide sheet. For each diagnostic property mentioned, the farmer was asked to describe the feature at different states of soil health. When answers to the initial open-ended question seemed complete, questions became framework-directed: interviewees were prompted about properties within the Interpretive Framework that they had not addressed.

Interview Analysis. The interviews were analyzed to determine the most important properties of soil health as perceived by farmers. These properties would then be the basis of a scorecard for soil health. Properties were considered greater in importance if they were: 1) mentioned earlier and more frequently, 2) mentioned in the open-ended question period rather than when respondents were framework-directed, and 3) used by the majority of the farmers. Properties were ranked as a function of the total percentage, sequence, frequency, and the ratio of unprompted to prompted answers. Descriptors obtained from the WICST farmers and other interviews were used as a basis for construction of a descriptive soil health scorecard questions to describe a specific property at different health levels.

Soil Health Scorecard. Construction of the soil health scorecard and establishment of measurement scales drew on human health science principles (Bowling, 1991; Streiner and Norman, 1989). Three levels of health were identified that concern functional ability: healthy, impaired and handicapped. A healthy body, soil or otherwise, is capable of performing a number of functions without any assistance or stress. As health declines, functional ability becomes impaired then handicapped, requiring increased intervention to perform a given function. Furthermore, many diagnostic properties of soil health are more a condition or state than a function. Scorecard questions were developed to address either a property's condition or functional ability to insure the index measured soil health adequately. Differential weighting of the scorecard questions was established based on the rank of the property. Other aspects of the scorecard are detailed later.

Table 4. Farm characteristics of 28 participants in the Soil Health Interview with respect to synthetic chemical input.

	Total	Synthetic Chemical Input[1]		
		Conventional	*Low*	*No*
County				
Walworth	14	6	8	–
Columbia	14	7	6	1
Operation				
Dairy/Livestock	10	3	7	–
Cash Grain/Vegetables	4	4	–	–
Grain/Livestock	14	5	8	1
Size (acres)				
Average	601	904	394	80
Range	80–2200	350–2200	125–850	80

[1] *Conventional* – recommended rates of synthetic fertilizers & pesticides, <25% N–credits taken, >50% corn in rotation, corn follows corn (>2yrs); *Low* – reduced rates of synthetic fertilizers & pesticides, 25–50% N–credits taken, 30–50% corn in rotation, corn rarely follows corn (≤2 yrs); *No* – no use of synthetic fertilizers & pesticides, >50% N–credits taken, <30% corn in rotation, corn never follows corn.

Results and Discussion

WICST Farmer Concepts of Soil Health. Analysis of the interviews identified properties of soil and non-soil target systems that farmers use to recognize a healthy soil. Figure 5 shows the top fifty properties of soil health categorized in accordance with our Interpretive Framework. Bold type is used to identify the top 20 properties. Soil components represented 60% of the properties the farmers used to recognize a healthy soil. Plant characteristics made up 30%, while properties pertaining to animal/human (6%) and water (4%) target systems were used less frequently. Qualities of the air target system were not considered important to soil health by these interviewees. The farmers tended to use sensory perceived properties (70%) rather than analytical properties (30%) for expressing soil health.

Most of the properties recognized by the farmers in a healthy soil were discrete categories. But with the development of questions to be used in soil health assessment, it became difficult to distinguish some properties from one another. For example, soil tests and levels of primary nutrients (nitrogen, phosphorous, and potassium) were all used by farmers to recognize a healthy soil, but on most occasions they were intermingled with one another. Because of this, a single question addressing soil test - N, P & K was included in the scorecard. Additionally, descriptions of the majority of analytical properties were more qualitative rather than concrete values. Of the 15 analytical properties, only pH, organic matter and yield were expressed as numerical values. Scorecard questions addressing the remaining analytical properties reflect the qualitative descriptions we received from farmers. In this sense, such properties are more descriptive than analytical when compared with the statistically expressed analytical data typically used by scientists to define soil quality.

The farmers had conflicting opinions about weed populations, soil type and slope characteristics of healthy and unhealthy soils. For example, several farmers believed a good stand of weeds indicated a healthy soil, while others thought it a sign of poor soil health. Soil type and slope had similar response patterns without any conclusive indicator of soil health and quality.

WICST Farmer-Based Soil Health Scorecard. Appendix IX presents the Farmer-based Soil Health Scorecard completed for rotation R5 (oats-alfalfa-corn) at Arlington Research Station. Scorecard construction involved grouping of the questions according to target system, starting with soil and progressing through the plant, animal/human, and water target systems; WICST farmers did not consider the air target system of sufficient importance to justify inclusion.

Scores for questions were weighted to reflect the rank of the property as determined by the interview analysis. Questions addressing the top 20 properties (bold print in Figure 5) were provisionally assigned a point value of 4 (healthy) to 0 (unhealthy). Questions addressing the next 30 questions were provisionally assigned a point value of 2 (healthy) to 0 (unhealthy). The remainder properties were rationalized as being insufficiently important to merit inclusion on the soil health scorecard. The scorecard was constructed to allow separate scores for the different target systems, as well as a total score, expressed as a percent of the maximum score for the system(s). In addition, allowance was made for questions that were not answered, either because they were inappropriate for a specific cropping system or because they were unanswered for other reasons.

It is important to recognize that the soil health scorecard represents a year-integrated, farmer assessment of soil health, and is optimally obtained retrospectively with

Figure 5. Top 50 properties farmers use to recognize a healthy soil, placed in their respective target system within the Interpretive Framework. The 20 properties that ranked highest are in bold type.

Category	Target System: Soil	Plant	Animal	Water
	——— Descriptive ———			
Look				
	soil erosion	**crop appearance**	human health	surface water appearance
	earthworms	**nutrient deficiency**	animal health	
	soil structure	**plant roots**	wildlife	
	infiltration	mature crop		
	soil color	weeds		
	surface mulch	plant growth		
	surface crust	resists drought		
	soil depth	resists pathogens		
		plant leaves		
		seed germination		
		plant stems		
Feel				
	compaction	–	–	–
	feel of soil			
	friability			
	soil texture			
Smell				
	soil smell	–	–	–
Taste				
	–	–	–	–
Look/Feel				
	drainage	–	–	–
	tillage			
	water retention			
	decomposition			
	biological activity			
	soil fertility			
	aeration			
	——— Analytical ———			
Chemical				
	pH	feed value	–	chemicals in groundwater
	soil test			
	nitrogen			
	phosphorous			
	potassium			
	micronutrients			
	Ca:Mg ratio			
Physical				
	soil type	**crop yield**	–	–
	slope	cost of production		
		grain test weight		
Biological				
	organic matter	–	–	–

the aid of seasonal notes, at the end of the growing season for a specific site.

It is also important to recognize that the soil health scorecard is driven solely by the results from the WICST farmer group interviewed, both in terms of the target systems and specific questions included in (and excluded from) the scorecard, and the relative weighting of the scorecard questions. Refinement of the soil health scorecard to reflect a broader farmer viewpoint will require structured input from a larger and more diverse group of farmers.

SOIL HEALTH AND QUALITY DATA FOR WICST

Materials and Methods

Descriptive Soil Health Properties and Scorecard. To collect descriptive information on soil health, field operators at each county site were familiarized with the soil health properties contained in the site-specific questionnaire (Garlynd et al. 1994) in the spring and summer of 1993. Although field operators do not share the same intimate relationship with the research plots as farmers do with their fields, they were the best qualified to make year integrated observations about the plots.

In the fall, the field operator at each site was asked a series of question concerning integrated soil properties and non-soil target system properties in the WICST plots. These questions were empirically determined based on earlier interactions with farmers and preliminary analysis of the WICST farmer interviews. The field operators were asked to recall and generalize how all three plots of a particular rotation behaved. Any individual plots that deviated from this generalized behavior were identified and noted. Direct soil descriptive properties such as structure, color, earthworms, surface crust and friability were observed and recorded by Garlynd and Romig during fall soil sampling.

The unavailability of the soil health scorecard until spring of 1994 required that results of the 1993 fall interviews of field operators had to be adjusted to reflect the outcome as if the scorecard (Appendix IX) had been used. Most questions posed to field operators were very similar to those in the scorecard. Questions addressing tillage, growth, erosion, mature crop, yield, drought and pathogen resistance were slightly modified to be compatible with the scorecard. The soil health scorecard also provides a more complete assessment of soil health, asking twice as many questions as the number we posed to the field operators. Scorecard questions that were not included in the field operator interviews are indicated as NI on the scorecard (Appendix IX). Questions that were not appropriate for the particular rotation are denoted as NA. Descriptive soil health scores for each rotation were obtained by averaging the results of the three plots in each rotation.

Analytical Soil Quality Properties and Scorecard. Measurements of the analytical soil quality properties were limited to the soil target system. Spring samples were collected before tillage or planting on April 25 at Arlington Research Station (ARS), and April 24 at Lakeland Agricultural Complex (LAC). Summer samples were taken on August 11 at both sites. Fall samples were collected after corn harvest, but before any manure was spread on November 3 at ARC and November 4 at LAC.

In 1993, rotation R1 (continuous corn [CC]) was sampled to compare to the corn phases of rotation R2 (soybean-corn [BC]), rotation R3 (soybean-winter wheat clover mix-corn [BWC]), rotation R5 (oats-alfalfa-corn [OAC]), as well as rotation R6 (permanent mixed pasture [PP]). Continuous corn represents the baseline conditions prior to the establishment of other rotations.

Soil sampling for chemical, physical, and biological analysis was consistent with last year's procedures (Harris et al. 1993). Samples were collected from the corn phase (plus [PP]) from blocks 1,2 and 3. Each plot had three 16m x 16m sampling stations established in them evenly spaced along their length. Each station was divided into a grid of 16 $4m^2$ substations. A single 3/4" core was collected from the plow layer (0-15cm) within the row at each substation. The 16 cores from each of the three stations were combined for a bulk sample of each plot consisting of 48 cores. This bulk sample represented one replicate for that respective rotation. Large cores (3"dia) were taken with a Uhlen sampler in spring and fall for measuring physical properties.

Nitrate and ammonium nitrogen, organic matter, pH, extractable phosphorous, exchangeable Ca, Mg, and K, particle size distribution, and electrical conductivity were conducted at the UW Soil and Plant Test Laboratory in Madison (Schulte et al. 1987). Available nutrients are soil quality indicators of nutrient cycling and microbial activity (Karlen et al. 1994), as well as productivity and environmental quality (Doran and Parkin, 1994). Particle size distribution is an indicator of retention and transport of water and chemicals and as a soil erosion and variability estimation parameter, and electrical conductivity and pH define biological and chemical activity thresholds (Doran and Parkin, 1994). Bulk density and total porosity were determined using the core method (Blake and Hartge, 1986; Danielson and Sutherland, 1986). Bulk density is a soil quality indicator of plant root growth, water and nutrient uptake (Karlen et al. 1994) and potential for leaching and productivity (Doran and Parkin, 1994). Total porosity is an indicator of water and air movement in the root zone (Karlen et al. 1994). Aggregate water stability was determined using the wet sieve method (Kemper and Rosenau, 1986). Aggregate water stability is an indication of a soil's structural development and resistance to disruption (Karlen et al. 1994). The larger size fraction (>2mm) may result from bonding by of filamentous hyphae; the smaller size fraction (>0.25) is more likely the result of bacterial exudates binding the soil particles together (Harris et al. 1966).

Several methods of estimating biological activity in the soil were evaluated: microbial biomass, labile organic carbon, arginine ammonification, and dehydrogenase activity. Gross microbial indicators of general community levels are more sensitive to differences between soils compared to measuring specific species (Bolton et al. 1985). Microbial biomass was estimated by the fumigation incubation method (Jenkinson and Powlson, 1976): Fifty grams of 5mm sieved soil was preincubated for 4 days followed by a 24 hour fumigation; fumigated and unfumigated soils were then incubated for 10 days at 25°C; a K-value of 0.45 was used for conversion to microbial biomass. Labile carbon was measured by evolution of CO_2 during incubation of 50 grams of 5mm sieved moist soil at 25°C over a period of 14 days; CO_2 was trapped by 0.5 N NaOH and measured by Technicon Autoanalyzer II (Morfaux et al. 1972). Microbial biomass and labile organic carbon are measurements of the overall level respectively of micro-organisms and available carbon energy source in the soil, and are indicators of resistance of soil to degradation and plant growth through nutrient cycling (Karlen et al. 1994; Doran and Parkin, 1994). Soil enzyme activities are general indicators of microbial communities size. Arginine ammonification was measured by a slightly modified standard procedure (centrifugation of KCl-soil extract was replaced by filtration) (Alef and Kleiner, 1986), and is a measure of the intracellular enzymes responsible for hydrolysis of C-N bonds by micro-organisms in soil. Dehydrogenase activity of soil was measured using the standard method (Casida et al. 1964), and is a measure of intracellular enzymes mainly linked with respiration processes of micro-organisms associated with the initial breakdown or soil organic matter (Ross, 1971). Arginine ammonification and especially dehydrogenase activity are analogous to respiration (Doran and Parkin, 1994) as indicators of biological activity and nutrient cycling.

Labile organic nitrogen was measured during 1992 baseline level establishment. The behavior of labile organic N measurement across the rotations was erratic and was felt to be an unreliable parameter of soil quality for this study. Labile organic N is not currently recognized in the minimum data sets of soil quality indicators used by Karlen et al. (1994) and Doran and Parkin (1994). Accordingly, labile organic N was dropped from our minimum data set of soil quality indicator properties for WICST.

Results and Discussion

Based on technical and grey literature considerations, long term effects of varying cropping system management on soil health and quality may be approximated for the WICST plots. With continuous corn (R1[CC]) as a reference system, the following changes in soil health and quality properties of the other systems would ultimately be predicted.

Levels of exchangeable nutrients (N, P, K, Mg) would be expected to decrease in the reduced input rotations R3[BWC], R5[OAC], and R6[PP]. These same rotations could also exhibit increased earthworm and microbial activity leading to enhanced crop performance indicators such as crop appearance, plant leaves and roots. R5[OAC], which receives manure, could show a more balanced pH (<7.0) especially in the fall when seasonal values tend to rise. Manuring may also cause increased microbial biomass levels and enzyme activity. Improvements of soil structure, water infiltration and absorption as well as organic matter levels would also be expected. Amounts of water stable aggregates are anticipated to rise as a result of no-till practices on R2[BC] and R6[PP]. Absence of soil surface disruption could result in improved infiltration, soil surface crust and earthworm activity. R3[BWC], R5[OAC], and R6[PP] could also eventually develop increased levels of water stable aggregates from the fine root growth of a small grain and/or hay crop. Bulk density would be lowered by the additional organic material added to the soil by these same cropping systems. The increased amounts and availability of food sources and associated microbial activity accompanying the spreading pattern of fine roots in R3[BWC], R5[OAC], and R6[PP] would likely increase microbial biomass and especially enzyme activity as well as raise organic matter levels. These improvements could lead to lower levels of compaction and soil hardness, higher micronutrient levels, and better soil fertility and crop performance indicators.

When interpreting results to date it is important to recognize how long the various rotations being examined have been established. During this early period of the WICST study, differences in the number of years specific rotations have been out of filler corn will inevitably affect the development of the ultimate descriptive and analytical characteristics of that cropping system. R1[CC] and R6[PP] have been established for 4 years since the onset of the study in 1990. R3[BWC] and R5[OAC] however, have had only 2 years to show any changes in soil quality and health caused by their specific rotations.

<u>Descriptive Soil Health Properties and Scores</u>. A major focus of this part of our project is to look for any changes in descriptive soil health properties resulting from shifting from continuous corn to the other rotations, that might precede quantitatively observable changes in soil quality. Table 5 summarizes the 1993 descriptive soil health results for the soil, plant, and combined target systems from fall observations and field operator interviews. As mentioned previously, these soil health scores were determined from questions chosen empirically and represent approximately 50% of what the scorecard evaluates (Appendix IX).

Acknowledging the relatively weak applicability of the scorecard to the 1993 descriptive data, soil health scores indicate that overall (combined target systems) soil health seems to be improved in rotation R2[BC] (both locations) and R5[OAC] and R6[PP] (ARS) compared to baseline rotation R1[CC]. Rotation R3[BWC] showed the only overall soil health score markedly lower than that of R1[CC] (Table 5).

If the target systems are examined separately, the source of the difference in the overall soil health scores becomes clear. The soil target system scores for Arlington and Lakeland showed an improvement for rotations R2[BC], R5[OAC] and R6[PP] compared to rotation R1[CC]. The plant target system scores show rotation R1[CC] to have some of the best plant quality/health, with rotation R3[BWC] (both locations) and R5[OAC] and R6[PP] (LAC) showing depressed scores. Thus, in relation to the overall soil health, the relatively high plant target system scores for continuous corn counterbalanced the improved soil target system scores for the other cropping systems.

Recognizing the limitations of the 1993 descriptive data, the observed trends identify a possible transitional phase from the continuous corn baseline to the other rotations. The soil target system score indicates the longer, more complex rotations of R5[OAC] and R6[PP] are improving the soil. However the plant target system score reflects a depression in the plant portion of the scorecard. This trend is consistent with the depressed yields and crop quality that has been shown to occur in a transition from high input farming to a lower input situation (USDA, 1980).

Plans for 1994 are to implement the complete soil health scorecard by having the farm operators log entries over the growing season and to complete a year-integrated scorecard in the fall. This will provide a comprehensive descriptive base for independent evaluation of cropping system effects on soil health, and for comparison of trends in soil health with trends in analytical soil quality data.

Table 5. Average soil health scores for selected WICST Rotations, Fall 1993.

Site	Target System	ROTATION SCORE[1] R1 (C–C–C*–C–C)[2]	R2 (C–B–C*–B–C)	R3 (B–Cl–C*–B–Cl)	R5 (O–A–C*–O–A)	R6 (P–P–P*–P–P)
		%[3]	%	%	%	%
Lakeland	Soil	63	67	59	69	68
	Plant	80	83	55	57	50
	Total	67	72	58	66	66
Arlington	Soil	78	81	80	86	86
	Plant	77	81	44	78	78
	Total	77	81	71	84	84

[1] Score based on field observations by Garlynd and Romig and the recollection of head field operator at each site.
[2] C=Corn, B=Soybeans, Cl=Wheat (fall)/Red Clover (spring), O=Interseeded Oats/Alfalfa, A=Alfalfa, P=Pasture. * 1993 sampling.
[3] Percentage of possible score for questions answered averaged over three plots within treatment.

Analytical Soil Quality Properties. As identified earlier, a collation procedure for transforming analytical soil quality data into an integrated soil quality score is not currently available. Accordingly, at this stage we are restricted to evaluating the effect of management and year-integrated, descriptive soil health trends, on individual soil analytical properties shown at a specific seasonal time, or in a seasonal pattern. Transformation of analytical data into soil quality scores based on functional groupings using a modification of the approach of Karlen et al. (1994) is underway.

Tables 6-8 present chemical, physical and biological soil properties for the Arlington and Lakeland sites as a function of season (spring, summer and fall) for 1993. The corn baseline data for 1992 are also included in the tables for comparison. The dat were subjected to statistical analysis using the SAS package (SAS Institute Inc., 1988) involving ANOVA and LSD computations. Statistical differences were determined at the 95% and the 99% certainty level, for each season, between the 1993 continuous corn baseline (bold data in the tables), and (1) the 1992 continuous corn system, and (2) the other 1993 rotations. Statistical tests were not run if the F-test was above the 0.05 reliability threshold (Snedecor and Cochran 1980).

Comparison of the soil properties of the 1993 to the 1992 continuous corn system allows evaluation of the utility of soil analytical measurements made in previous years to gauge cropping system related changes over time. For the majority of soil analytical properties, there was no significant difference between the 1993 CC and 1992 CC systems within the same season (Tables 3-5). However, sufficient exceptions existed to mandate use of same-year baseline CC data for assessing the effect of cropping system on soil analytical properties.

Comparison of the 1993 R1[CC] soil analytical properties to those of the other rotations sampled in 1993 provides information on the short term response of soil quality associated with a shift from continuous corn to integrated cropping systems. Many chemical soil properties (Table 6A and 6B) showed a significant difference between the CC baseline as compared to the other cropping systems, for all three seasons, at both locations. For example significantly lower values for fall nitrogen were shown at Lakeland, and fall phosphorus and potassium at Arlington. The higher values for nitrogen at Lakeland and P and K for Arlington over the low input rotations of R3[BWC] and R5[OAC] may be the result of carry over nutrients from the increased fertilization of R1[CC].

Soil physical properties (Table 7A and 7B) showed little response to the shift from continuous corn. The increased aggregate stability in summer for all the rotations may be caused by the flush of microbial activity and root growth accompanied by exudate secretion (Kay, 1990).

Biological activity was measured by microbial biomass, labile C, arginine ammonification, and dehydrogenase activity (Table 8A and 8B). Microbial biomass showed significant increases compared to R1 [CC] in the spring and fall for most rotations at both locations. A significant difference was found between R1 [CC] and R6 [PP] in all but one season. Because of the extensive fine root systems in the permanent pasture rotation, rapid nutrient cycling indicated by elevated microbial biomass would be expected. Labile C exhibits a plateau during summer sampling season that could be the result of increased bioactivity resulting in partial breakdown of the available carbon energy sources. Enzyme assays show steadily increasing values throughout the year. This could be explained by the fact that the populations with these enzymatic capabilities were building up throughout the season.

Meaningful interpretation of the effect of the shift from continuous corn on analytical soil quality properties as related to descriptive soil health properties, awaits planned development of methodology for collating soil analytical properties into soil quality scores, availability of the 1994 soil quality data, and direct application of the soil health scorecard to the WICST sites.

Table 6A. Soil chemical properties of continuous corn plots for 1992 and 1993, and other selected rotations for 1993 at Lakeland. The 1993 continuous corn baseline data are in bold type.

SEASON and YEAR	ROTATION[1]	PROPERTIES[2]							
		pH (−log[H^+])	Nitrate N (mg kg^{-1})	Ammonium N (mg kg^{-1})	Ext P (mg kg^{-1})	Exch Ca (mg kg^{-1})	Exch Mg (mg kg^{-1})	Exch K (mg kg^{-1})	CEC (meq $100g^{-1}$)
SPRING 1993	**R1**	**6.6**	–	–	**58**	**2083**	**633**	**193**	**19**
	R3	6.4	–	–	45	2083	637	168	19
	R5	6.7	–	–	71	2400	760	207	22
	R6	6.9	–	–	62	2733	867 a	183	25
SUMMER 1992	R1	6.7	18	5 b	51	2050	723	257	17
	R4	6.8	34	6 b	42	2633	943	210	21
1993	**R1**	**6.5**	**23**	**14**	**57**	**1850**	**643**	**170**	**18**
	R3	6.5	16	11	42	2000	690	155	19
	R5	6.9 b	19	14	69	2167	790	183	21
	R6	6.9 a	23	17	50	2700	927 a	173	25
FALL 1992	R1	6.8	10	4 b	49	2000	720	230	16
	R4	7	8	4 b	62	2700	967	277	21
1993	**R1**	**6.8**	**24**	**15**	**47**	**2183**	**780**	**188**	**21**
	R2	6.9	18 b	12	36	2517	887	127	24
	R3	6.8	20 a	8 a	33	2283	803	160	22
	R5	7.0	22 a	8 a	60	2517	907	188	24
	R6	6.9	21 a	8 a	42	2900	1023	173	27

[1]Key to rotations:

R1 (C−C*−C*−C−C); In 1992 & 1993 plots #101, #210,#303 (treatment 1)
R2 (C−B−C*−B−C); In 1993 plots #113, #206, #311 (treatment 3)
R3 (B−Cl−C*−B−Cl); In 1993 plots #111, #208, #306 (treatment 6)
R4 (F−F*−C−A−A); In 1992 plots #107, #205, #309 (treatment 10)
R5 (0−A−C*−O−A); In 1993 plots #105, #207, #309 (treatment 12)
R6 (P−P−P*−P−P); In 1993 plots #104, #213, #314 (treatment 14)
Where F = Filler Corn, C = Corn, A = Alfalfa, B = Soybeans, Cl = Wheat (fall seeded) and Red Clover (spring seeded)
O = Interseeded Oats and Alfalfa, P = Pasture, and * indicates where in cropping pattern rotation was sampled

[2]a − values are significantly different from R1 ($P < .05$)
b − values are significantly different from R1 ($P < .01$)

Table 6B. Soil chemical properties of continuous corn plots for 1992 and 1993, and other selected rotations for 1993 at Arlington. The 1993 continuous corn baseline data are in bold type.

SEASON and YEAR	ROTATION[1]	PROPERTIES[2]							
		pH $(-\log[H^+])$	Nitrate N (mg kg^{-1})	Ammonium N (mg kg^{-1})	Ext P (mg kg^{-1})	Exch Ca (mg kg^{-1})	Exch Mg (mg kg^{-1})	Exch K (mg kg^{-1})	CEC (meq 100g^{-1})
SPRING 1993	**R1**	**6.8**	**–**	**–**	**97**	**1800**	**557**	**277**	**17**
	R3	6.9	–	–	65 a	1717	570	208	16
	R5	6.9	–	–	68 a	1800	583	187	17
	R6	6.7	–	–	96	1933	603	217	18
SUMMER 1992	R1	6.7	33	5 b	92	1783	610	325	15 a
	R4	6.7	36	5 b	85	1875	660	323	15 a
1993	**R1**	**6.7**	**24**	**18**	**92**	**1800**	**597**	**287**	**17**
	R3	6.9	13	14	58 a	1633	590	178 b	16 a
	R5	7.0	18	21	62 a	1750	620	153 b	17
	R6	6.7	23	16	72	1867	660	163 b	18
FALL 1992	R1	6.8	13 b	4 a	102	1833	630	402	15 b
	R4	6.9	15 b	4 a	81	1917	687	312	16 a
1993	**R1**	**7.0**	**24**	**9**	**93**	**2000**	**670**	**312**	**19**
	R2	7.0	24	9	69 a	1850	663	232	18
	R3	7.1	18	8	49 b	1950	707	170 b	19
	R5	7.1	29 a	10	65 a	1983	700	188 a	19
	R6	6.9	19	11	82	2000	707	210 a	19

[1] Key to rotations:

R1 (C–C*–C*–C–C); In 1992 & 1993 plots #109, #204, #306 (treatment 1)
R2 (C–B–C*–B–C); In 1993 plots #101, #214, #303 (treatment 3)
R3 (B–Cl–C*–B–Cl); In 1993 plots #102, #212, #313 (treatment 6)
R4 (F–F*–C–A–A); In 1992 plots #107, #205, #309 (treatment 10)
R5 (O–A–C*–O–A); In 1993 plots #103, #213, #314 (treatment 12)
R6 (P–P–P*–P–P); In 1993 plots #112, #207, #302 (treatment 14)
Where F = Filler Corn, C = Corn, A = Alfalfa, B = Soybeans, Cl = Wheat (fall seeded) and Red Clover (spring seeded)
O = Interseeded Oats and Alfalfa, P = Pasture, and * indicates where in cropping pattern rotation was sampled

[2] a – values are significantly different from R1 ($P < .05$)
b – values are significantly different from R1 ($P < .01$)

Table 7A. Soil physical properties of continuous corn plots for 1992 and 1993, and other selected rotations for 1993 at Lakeland. The 1993 continuous corn baseline data are in bold type.

SEASON and YEAR	ROTATION[1]	PROPERTIES[2]				
		Bulk Density (g cm^{-3})	Total Porosity (%)	Aggregate Stability >2mm (%)	Aggregate Stability >.25mm (%)	Electrical Conductivity ($x10^{-5}$ mhos cm^{-1})
SPRING 1993	**R1**	**1.18**	**55**	**1.6**	**33**	**12**
	R3	1.31	51	5.1 a	35	15
	R5	1.33	50	4.6 a	42	17 a
	R6	1.24	53	8.0 b	53 a	19 b
SUMMER 1992	R1	–	–	9.4	55 a	14
	R4	–	–	11.3	54 a	18
1993	**R1**	**–**	**–**	**14.6**	**75**	**10**
	R3	–	–	15.0	39	8
	R5	–	–	16.0	62	6
	R6	–	–	21.6	75	7
FALL 1992	R1	–	–	13.5	55	16
	R4	–	–	14.1	55	14
1993	**R1**	**1.22**	**54**	**12.9**	**41**	**9**
	R2	1.32	50	7.3 a	37	6
	R3	1.24	53	16.4	45	6
	R5	1.17	56	16.4	47	6
	R6	1.21	54	14.4	43	6

[1]Key to rotations:

R1 (C–C*–C*–C–C); In 1992 & 1993 plots #101, #210,#303 (treatment 1)

R2 (C–B–C*–B–C); In 1993 plots #113, #206, #311 (treatment 3)

R3 (B–Cl–C*–B–Cl); In 1993 plots #111, #208, #306 (treatment 6)

R4 (F–F*–C–A–A); In 1992 plots #107, #205, #309 (treatment 10)

R5 (0–A–C*–O–A); In 1993 plots #105, #207, #309 (treatment 12)

R6 (P–P–P*–P–P); In 1993 plots #104, #213, #314 (treatment 14)

Where F = Filler Corn, C = Corn, A = Alfalfa, B = Soybeans, Cl = Wheat (fall seeded) and Red Clover (spring seeded)

O = Interseeded Oats and Alfalfa, P = Pasture. and * indicates where in cropping pattern rotation was sampled

[2]a – values are significantly different from R1 ($P < .05$)

b – values are significantly different from R1 ($P < .01$)

Table 7B. Soil physical properties of continuous corn plots for 1992 and 1993, and other selected rotations for 1993 at Arlington. The 1993 continuous corn baseline data are in bold type.

SEASON and YEAR	ROTATION[1]	PROPERTIES[2]				
		Bulk Density (g cm^{-3})	Total Porosity (%)	Aggregate Stability >2mm (%)	Aggregate Stability >.25mm (%)	Electrical Conductivity ($x10^{-5}$ mhos cm^{-1})
SPRING						
1993	**R1**	**1.16**	**56**	**5.3**	**35**	**12**
	R3	1.31	51	4.1	33	13
	R5	1.16	56	2.5 a	37	15 b
	R6	1.27	52	5.3	43	13 a
SUMMER						
1992	R1	–	–	5.7	54	15 b
	R4	–	–	5.1	43	18 b
1993	**R1**	–	–	**12.9**	**68**	**6**
	R3	–	–	13.6	60	6
	R5	–	–	11.7	61	7
	R6	–	–	12.4	67	6
FALL						
1992	R1	–	–	6.1	45	12 b
	R4	–	–	6.4	43	12 b
1993	**R1**	**1.19**	**55**	**5.0**	**34**	**6**
	R2	1.38	48	4.4	39	6
	R3	1.32	50	4.2	39	6
	R5	1.14	57	9.5	32	6
	R6	1.28	52	13.8	50 a	6

[1]Key to rotations:

R1 (C–C*–C*–C–C); In 1992 & 1993 plots #109, #204, #306 (treatment 1)
R2 (C–B–C*–B–C); In 1993 plots #101, #214, #303 (treatment 3)
R3 (B–Cl–C*–B–Cl); In 1993 plots #102, #212, #313 (treatment 6)
R4 (F–F*–C–A–A); In 1992 plots #107, #205, #309 (treatment 10)
R5 (O–A–C*–O–A); In 1993 plots #103, #213, #314 (treatment 12)
R6 (P–P–P*–P–P); In 1993 plots #112, #207, #302 (treatment 14)
Where F = Filler Corn, C = Corn, A = Alfalfa, B = Soybeans, Cl = Wheat (fall seeded) and Red Clover (spring seeded)
O = Interseeded Oats and Alfalfa, P = Pasture, and * indicates where in cropping pattern rotation was sampled

[2]a – values are significantly different from R1 ($P < .05$)
b – values are significantly different from R1 ($P < .01$)

Table 8A. Soil biological properties of continuous corn plots for 1992 and 1993, and other selected rotations for 1993 at Lakeland. The 1993 continuous corn baseline data are in bold type.

SEASON and YEAR	ROTATION[1]	PROPERTIES[2]				
		Organic Matter (%)	Labile Carbon ($ugC\ g^{-1}$)	Microbial Biomass ($mgC\ 100g^{-1}$)	Arginine Ammonification ($ugN\ 10g^{-1}h^{-1}$)	Dehydrogenase Activity ($ugTPF\ 10g^{-1}h^{-1}$)
SPRING 1993	**R1**	**4.3**	**187**	**353**	**13.2**	**41**
	R3	4.2	173	365	22.0 b	32
	R5	4.8	201	402	17.6 a	30
	R6	5.6	270	546 a	20.0 b	42
SUMMER 1992	R1	4.2	84 a	293 a	20.5	63
	R4	5.1	90 a	308 a	23.7	63
1993	**R1**	**4.7**	**183**	**398**	**–**	**40**
	R3	4.6	194	360	–	32
	R5	5.1	244	489	–	44
	R6	6.5 a	316	551	–	40
FALL 1992	R1	4.2	142	306	26.3	73 b
	R4	5.2	113	408	23.7	68 b
1993	**R1**	**4.6**	**136**	**344**	**28.6**	**34**
	R2	4.6	155	293	23.3	29
	R3	4.7	196 b	367	23.6	42
	R5	5.1	131	487 b	24.7	32
	R6	6.0	152	699 b	23.7	41

[1]Key to rotations:

R1 (C–C*–C*–C–C); In 1992 & 1993 plots #101, #210,#303 (treatment 1)
R2 (C–B–C*–B–C); In 1993 plots #113, #206, #311 (treatment 3)
R3 (B–Cl–C*–B–Cl); In 1993 plots #111, #208, #306 (treatment 6)
R4 (F–F*–C–A–A); In 1992 plots #107, #205, #309 (treatment 10)
R5 (O–A–C*–O–A); In 1993 plots #105, #207, #309 (treatment 12)
R6 (P–P–P*–P–P); In 1993 plots #104, #213, #314 (treatment 14)
Where F = Filler Corn, C = Corn, A = Alfalfa, B = Soybeans, Cl = Wheat (fall seeded) and Red Clover (spring seeded)
O = Interseeded Oats and Alfalfa, P = Pasture, and * indicates where in cropping pattern rotation was sampled

[2]a – values are significantly different from R1 ($P < .05$)
b – values are significantly different from R1 ($P < .01$)

Table 8B. Soil biological properties of continuous corn plots for 1992 and 1993, and other selected rotations for 1993 at Arlington. The 1993 continuous corn baseline data are in bold type.

SEASON and YEAR	ROTATION[1]	PROPERTIES[2]				
		Organic Matter (%)	Labile Carbon (ugC g^{-1} ODso	Microbial Biomass (mgC 100g^{-1})	Arginine Ammonification (ugN 10g^{-1}h^{-1})	Dehydrogenase Activity (ugTPF 10g^{-1}h^{-1})
SPRING						
1993	**R1**	**4.3**	**216**	**242**	**15.1**	**44**
	R3	3.7	228	369 a	19.5	42
	R5	4.0	226	324	29.1 a	47
	R6	4.6	232	539 b	24.5	64 a
SUMMER						
1992	R1	4.3	107 b	255	21.8	70
	R4	4.4	94 b	268	18.8	70
1993	**R1**	**4.8**	**313**	**288**	–	**44**
	R3	3.8	273	260	–	40
	R5	4.2	226	334	–	56
	R6	4.8	321	535 b	–	47
FALL						
1992	R1	4.4	125	249	22.6	89 b
	R4	4.2	136	241	21.7	73 a
1993	**R1**	**4.8**	**168**	**309**	**23.7**	**44**
	R2	4.1	58 b	322 a	20.9	38
	R3	4.0	82 b	328 a	29.4	36
	R5	4.3	134	311	22.5	54
	R6	5.0	163	395 b	25.1	52

[1]Key to rotations:

R1 (C–C*–C*–C–C); In 1992 & 1993 plots #109, #204, #306 (treatment 1)
R2 (C–B–C*–B–C); In 1993 plots #101, #214, #303 (treatment 3)
R3 (B–Cl–C*–B–Cl); In 1993 plots #102, #212, #313 (treatment 6)
R4 (F–F*–C–A–A); In 1992 plots #107, #205, #309 (treatment 10)
R5 (O–A–C*–O–A); In 1993 plots #103, #213, #314 (treatment 12)
R6 (P–P–P*–P–P); In 1993 plots #112, #207, #302 (treatment 14)
Where F = Filler Corn, C = Corn, A = Alfalfa, B = Soybeans, Cl = Wheat (fall seeded) and Red Clover (spring seeded)
O = Interseeded Oats and Alfalfa, P = Pasture, and * indicates where in cropping pattern rotation was sampled

[2]a – values are significantly different from R1 ($P < .05$)
b – values are significantly different from R1 ($P < .01$)

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B. A Survey of Soil Macroarthropods Associated with Corn in Alternative Cropping Systems, 1992

D. K. Young, D. B. Hogg, and E. J. Rebek

Background

The Wisconsin Integrated Cropping Systems Trial provides a unique laboratory for examining the ecological ramifications, both short and long term, of different approaches to farming and philosophies of land stewardship. Much of the ecological "action" will take place in and on the soil, and will be related to the health of the soil as measured in chemical, physical and biological terms. A correlate to, and presumably an indicator of, soil health is the abundance and diversity of animals utilizing the soil habitat. Numerous recent studies suggest that a thorough analysis of agroecosystems requires consideration of the insects and other arthropods.

Our operational hypothesis going into the study of arthropod diversity was that *the level and frequency of soil disturbance (both chemical and physical) in the cropping systems would influence the numbers and kinds of arthropods existing in the plots*. Differences in arthropod populations could contribute to, as well as result from, changes in soil characteristics. The four systems in corn during the 1992 field season provided a range of chemical inputs, from the high end (continuous corn) to essentially no inputs for a two year rotation; however, the levels of soil disturbance (see graphs for tillage dates) were not as clearly delineated in the systems.

A similar, but slightly scaled down version of the basic diversity study was also conducted during the summer of 1993; these samples are still being processed.

Methods

The 1992 and 1993 surveys were conducted at both locations (Arlington Research Station [= ARS] and Lakeland Agricultural Complex [= LAC]) from early June through late August. Sampling was accomplished using pitfall traps, which passively capture animals as they move on the soil surface. Although not an exhaustive species inventory strategy, we felt that this sampling method would provide a basis for treatment and site comparisons in a standard way. [Since the 1993 data are still being processed at the time of this report, the following summary relates to the biodiversity pitfall trapping study conducted during the 1992 season.]

The "corn phase" of the cropping systems was sampled; treatments in the corn phase during the 1992 field season included, continuous corn (**T1**), drilled soybean-corn (**T2**), 30"-row soybean/winter wheat/red clover-corn (**T5**), and rapid turn around alfalfa (**T11**). [Note: The fifth corn rotation, the "green gold alfalfa", was not available in 1992, and was not included in the study.]

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* Assoc. Professor, Professor and undergraduate student, Dept. of entomology, Univ of Wisconsin, Madison, respectively.

Four pitfall traps were placed in each plot, in each of the four replications at each site. Trapping began in early June and terminated in early August. Like samples were pooled for comparison; thus, the contents of 16 traps (4/plot x 4 replications/site) constituted the bulk sample for each treatment. Traps at each field location were emptied weekly.

Results to Date

The arthropod abundance was clearly a surprise; we were literally overwhelmed by the material that needed to be handled. We have now separated, cleaned, and completed the first (rough) taxonomic "cut" of the trap residues for both field sites. In this first sorting step, the material goes through an alcohol wash to remove other organic debris and soil, and the specimens are sorted into major ("first order") taxonomic groupings. As we continue to process the material, groups of particular interest and diversity, such as the beetles (Coleoptera) will be further processed taxonomically. This will enable us to make more specific taxonomic comparisons, and to better identify "functional groups" in an ecological sense.

As a first basis of comparison, however, we have completed a preliminary analysis of the data available (see attached figures 6-13 of results for each of the first order taxonomic groups: Diplopoda, *millipedes*; Chilopoda, *centipedes*; Opiliones, *harvestmen*; Araneae, *spiders*; Collembola, *springtails*; Orthoptera, *crickets, grasshoppers, etc.*; Coleoptera, *beetles*; and Formicidae, *ants*). A cursory look at the graphs clearly illustrates that even at this, the first and "grossest" analysis, obvious differences exists - both between treatments, and between sites. For example, the Diplopoda, functionally scavengers for the most part, were almost entirely lacking at LAC. Conversely, Orthoptera populations were very low at ARS throughout the season. It can also be seen that at ARS, millipede populations were much higher, at least early in the season, in the rotations (**T2**, **T5**, and **T11**) as compared to continuous corn (**T1**). The [predaceous] Chilopoda, on the other hand were more abundant at LAC than ARS, except for the continuous corn treatment (**T1**), for which chilopod populations were depressed at both sites. The centipede populations at T5/LAC peaked dramatically between weeks 6 and 8. This could well be directly related to the very high T5/LAC populations of Collembola during that same period of time, in that the springtails probably represent a common prey item for the chilopods. Similar responses may be seen in the T5/LAC Coleoptera. In this group, predaceous species of ground beetles (Carabidae) form the dominant group. In the case of the Opiliones, the harvestmen or "daddy-long-legs, and spiders (Aranae) population responses were remarkably similar at the two sites, with the ARS populations slightly more numerous.

Also of interest were the peaks and dips in population abundances at certain times of the season. Although we have not yet attempted to interpret these findings, they very well may have ecological significance. For example, Collembola populations showed a conspicuous increase around week four of the study; this is illustrated to a greater or lesser extent at both sites, and over all treatments. Also of interest (around sampling week two: 10-17 June) is the dip in Collembola numbers at LAC in the rotation treatments (**T2**, **T5**, and **T11**) as compared to a rise in Collembola numbers in the continuous corn treatment (**T1**). ARS Collembola populations were extremely similar throughout the season between treatments 5 and 11; seasonal population of the T2 soybean-corn rotation was far more similar to the T1 continuous corn than to either T5 or T11.

The bimodal population abundance distribution of Orthoptera at T11/LAC is rather unique. No other T5 group showed this response at LAC, although the ants (Formicidae) generally exhibited something of a bimodal pattern at all ARS sites, with ant populations highest at the beginning and end of the sampling period.

Again, these graphic representations must be looked at with some caution: remember that they represent but the first order of taxonomic sorting. Regardless, these preliminary data do appear to support our initial research hypothesis for the study: *the level and frequency of soil disturbance (both chemical and physical) in the cropping systems do influence the numbers and kinds of arthropods existing in the plots*. As a corollary, it does appear that arthropod abundance and diversity can be used as an ecological "indicator" of soil (= community) health.

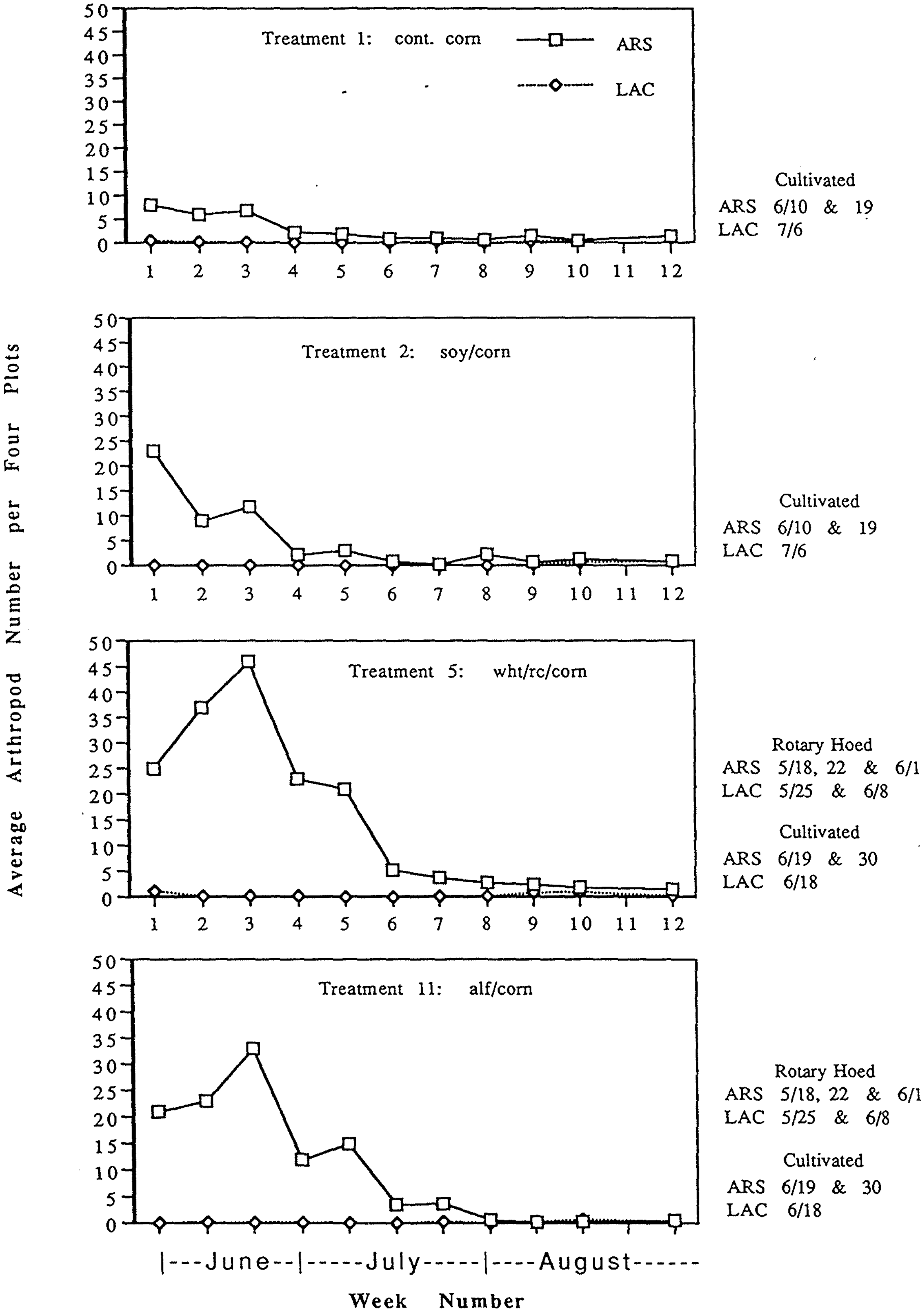

Figure 6. Diplopoda Captured in WICST Pitfall Traps - 1992

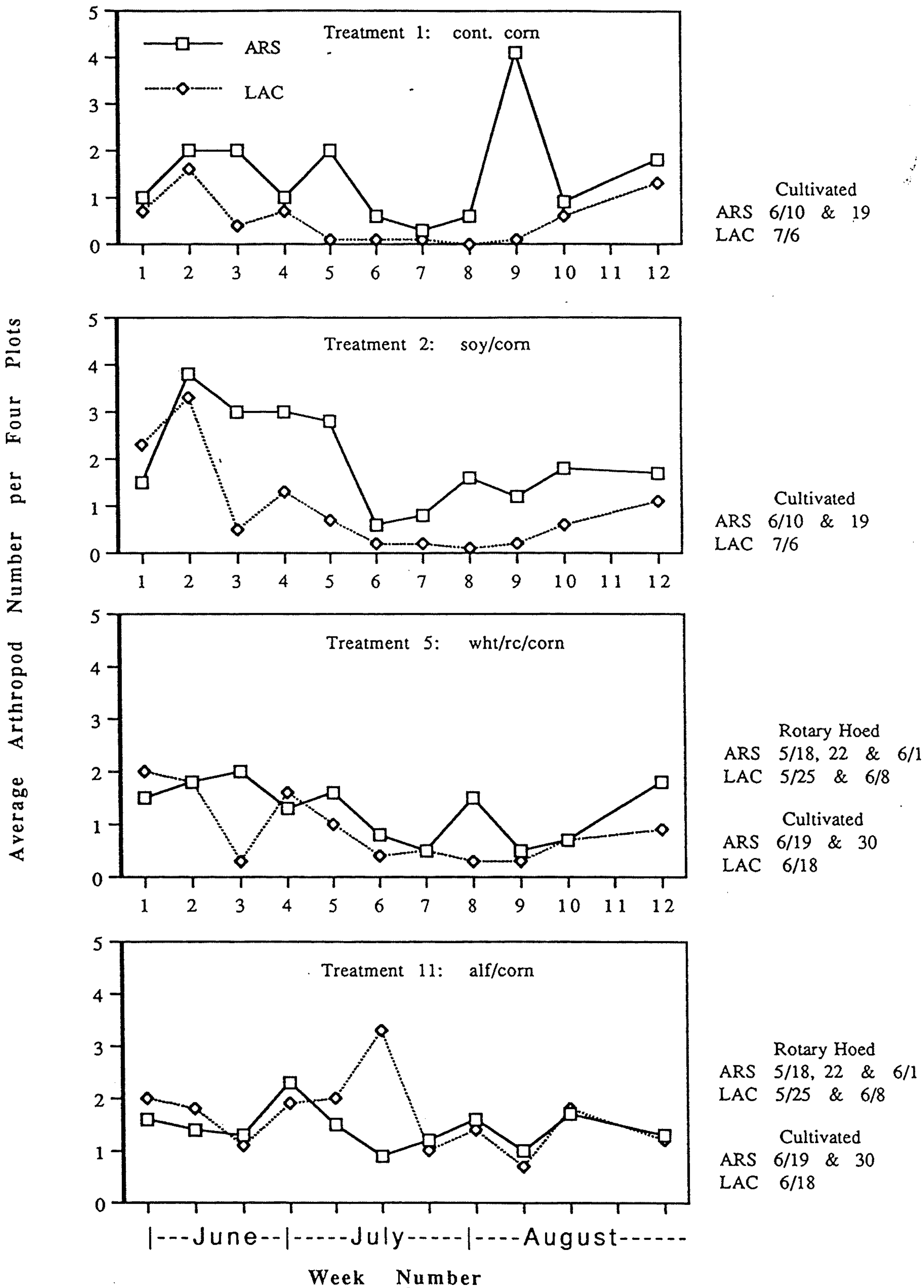

Figure 9. Aranaae Captured in WICST Pitfall Traps - 1992

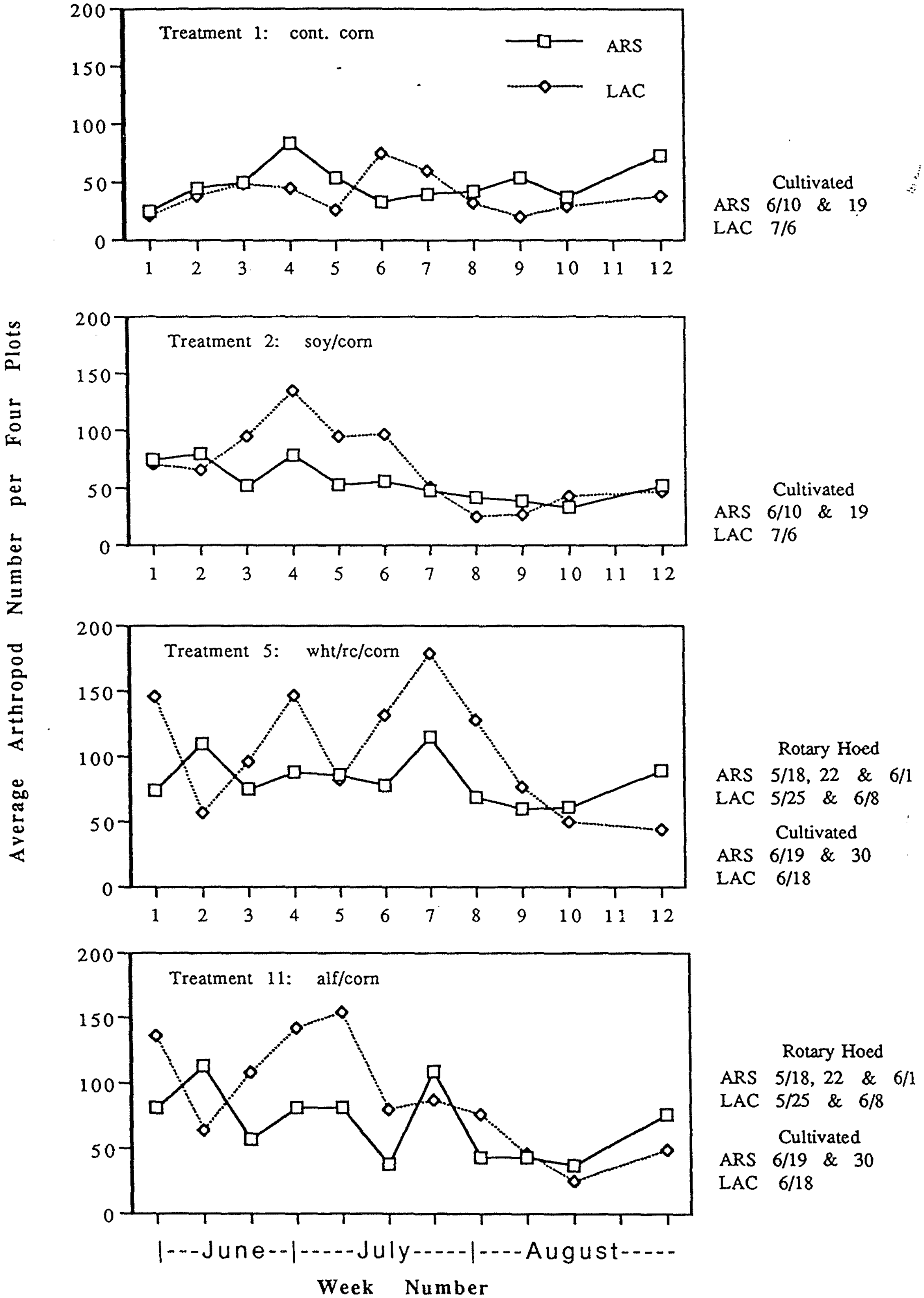

Figure 10. Collembola Captured in WICST Pitfall Traps - 1992

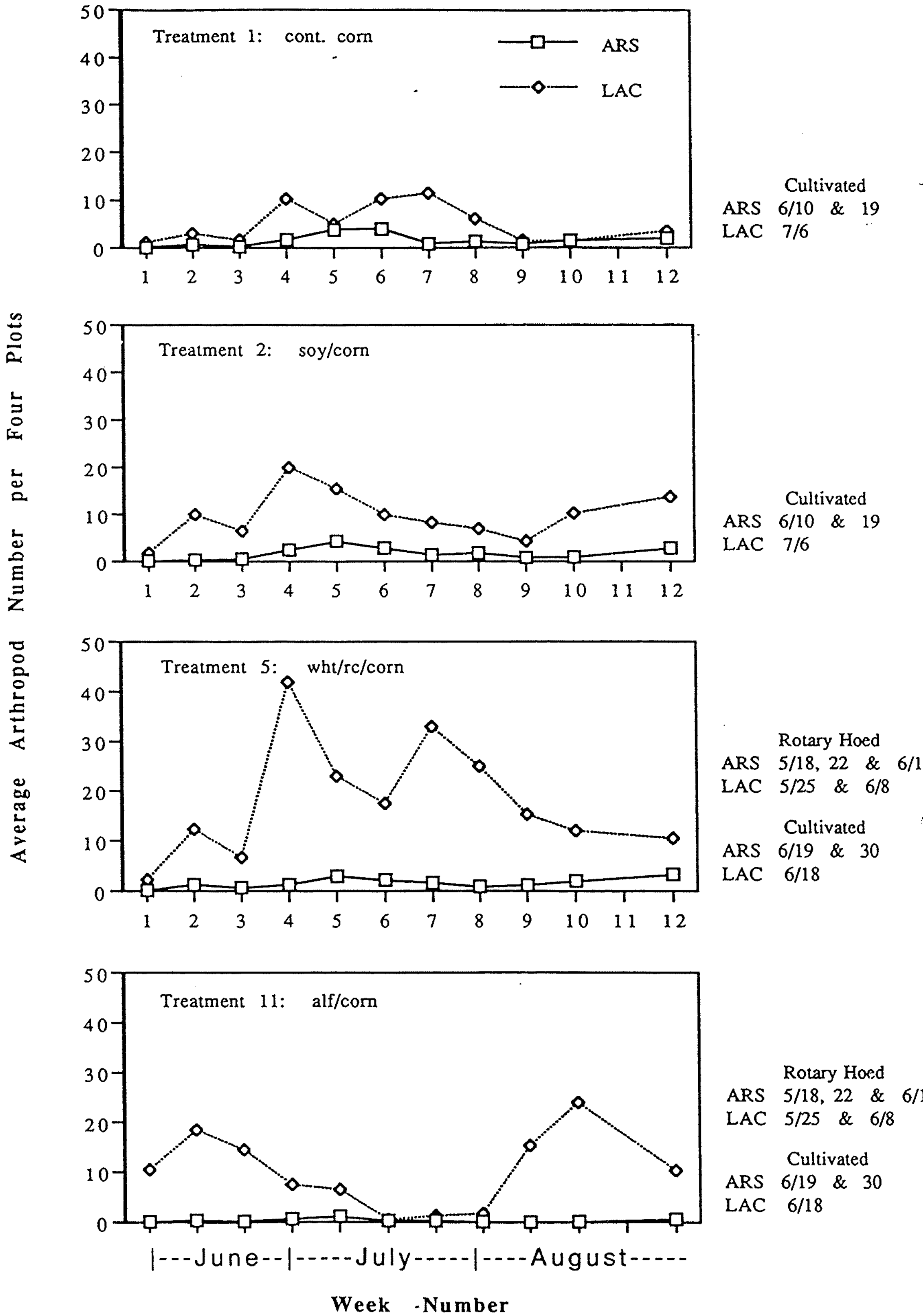

Figure 11. Orthoptera Captured in WICST Pitfall Traps - 1992

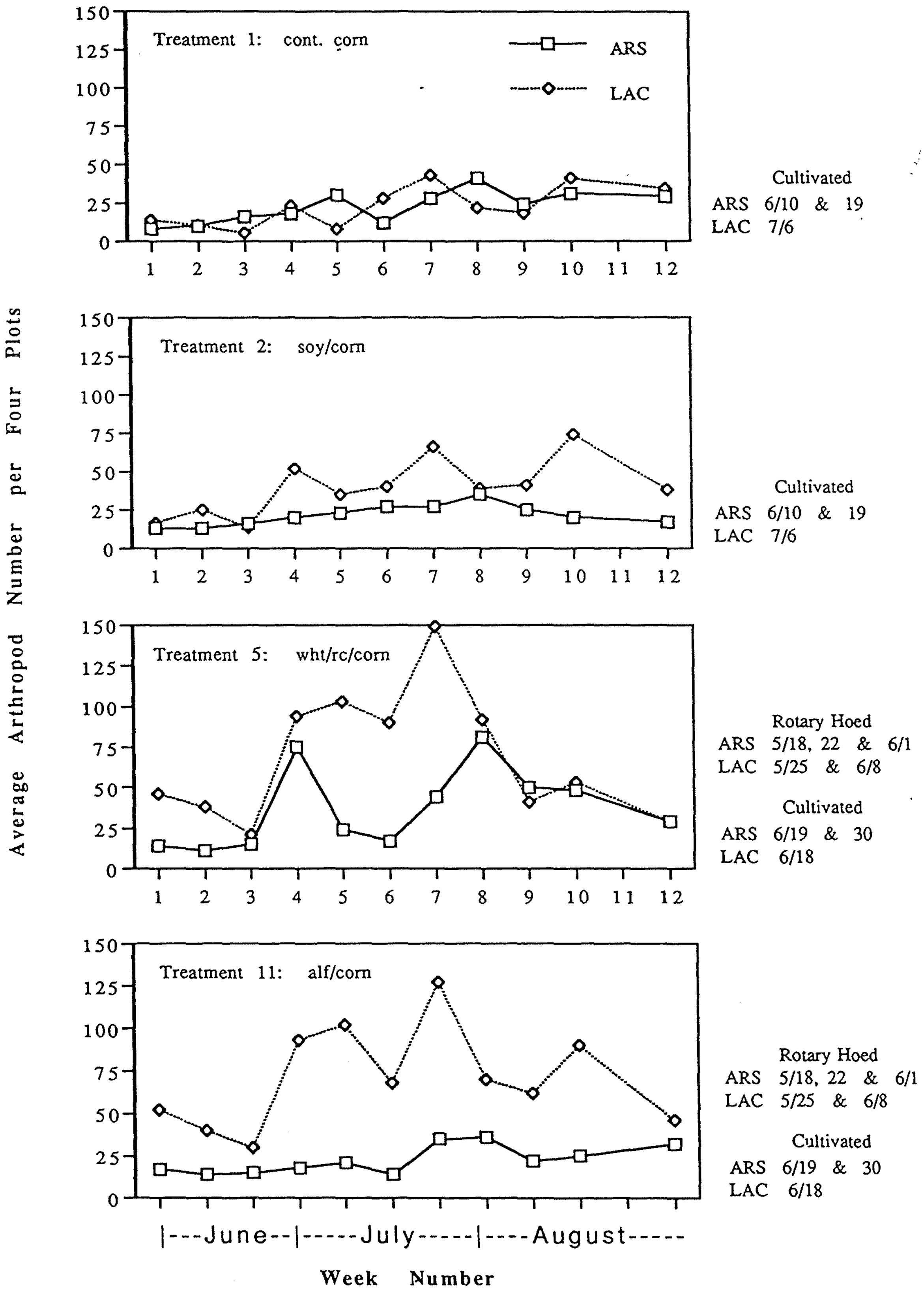

Figure 12. Coleoptera Captured in WICST Pitfall Traps - 1992

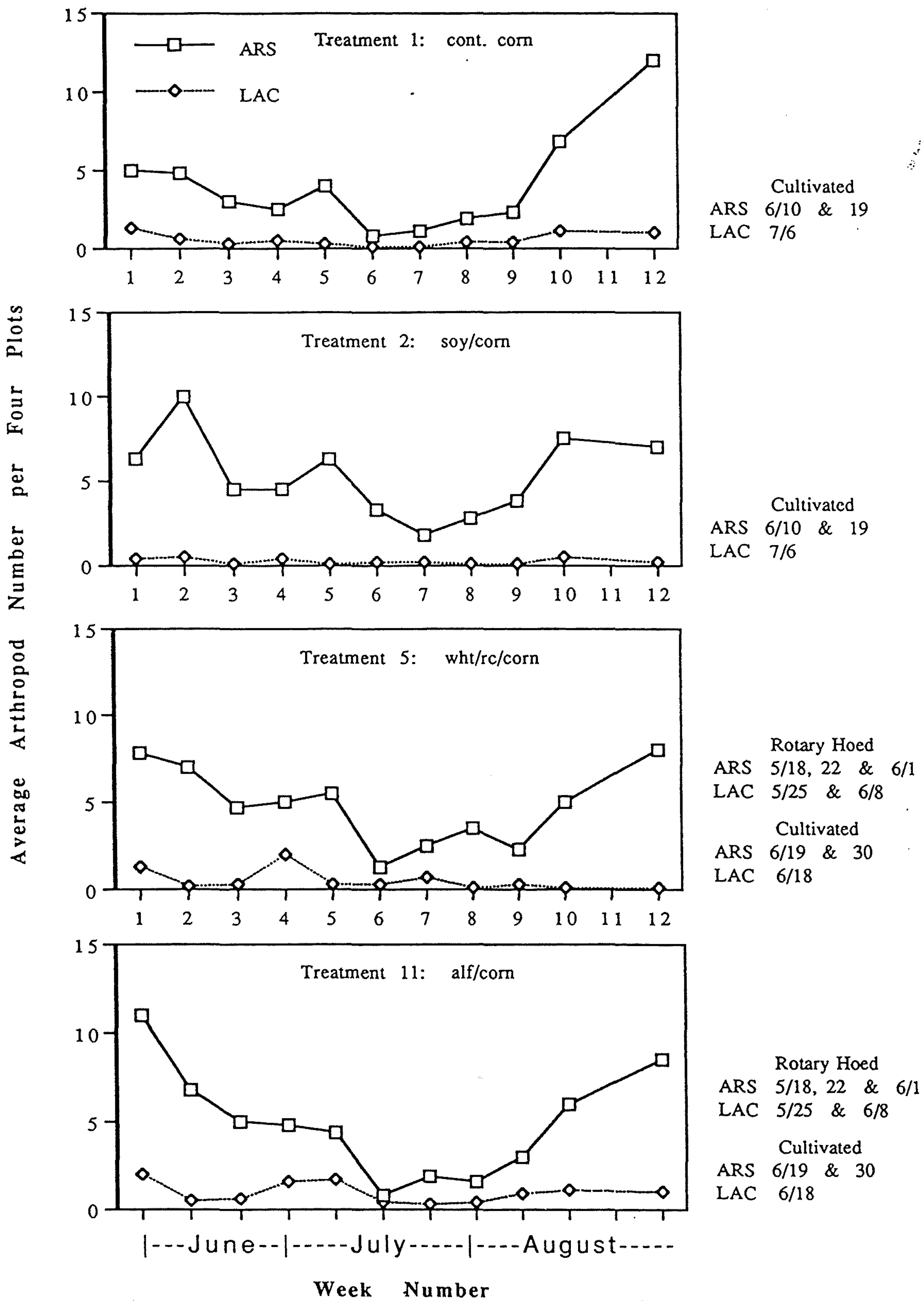

Figure 13. Formicidae Captured in WICST Pitfall Traps - 1992

C. Residue Decomposition Following Corn in Three Cropping Systems: 1993 Results

D.B. Hogg*, D.K. Young*, Hugo Hoffman** and E.J. Rebek*

To characterize the influence of crop rotation on residue decomposition, a litter bag study was initiated on the Wisconsin Integrated Cropping Systems Trial (WICST) during 1993. It has been suggested that enhanced efficiency of lower input systems is due to increased soil biological activity resulting in a more rapid decomposition of residue and improved nutrient retention. Our hypothesis was that in the R3 rotation (Sb/W-W/RC-C) residue breakdown would be more rapid than in, for example, the continuous corn rotation (R1). Our secondary hypothesis was that the increased rate of decomposition would be, in large part, due to the increased soil fauna activity assumed to be associated with rotations that don't use insecticides, had good ground cover, and included plow-down leguminous material (again R3 > R1). In an effort to characterize soil biological activity and test these hypotheses, we estimated decomposition rates of corn residue using litter bags with different pore sizes to measure the rate of decomposition and isolate the effects of microorganisms and soil fauna.

Methods

Both the Arlington (ARS) and Lakeland (LAC) sites of the WICST were included in a litter bag sampling program. Bags with different mesh sizes were utilized to indicate the relative importance of animal activity in the decomposition process (Edwards and Heath, 1963; Curry, 1969; Vossbrinck et al., 1979; House and Stinner, 1987). Bags with pore size of 0.0053 mm were used to exclude annelids and arthropods, allowing only microorganisms to enter, and bags with pore size of 4 mm were used to allow all soil fauna to enter.

Corn residue decomposition rates were monitored following the corn phase in three of the six rotations in WICST: continuous corn (C-C); the low-input, three-phase cash grain system (Sb/W-W/RC-C); and the three-phase forage rotation (O/A-A-C). Corn residue, harvested in the fall and stored outside for the winter, was placed in 10 by 20 cm nylon mesh bags. Approximately 12-15 grams of air-dried residue, including both leaf and stalk tissue, was placed in each bag. In mid-May, after pre-plant cultivating and planting, the bags were buried by inserting them into the soil on a slant, near the soil surface, approximating the deposition of residue after chisel plowing.. Twenty sets of bags of each pore size were placed in each of the treatments to be monitored, five in each of the four replications. This permitted five monthly samples to be taken beginning in mid-June. After collection, bags were weighed and the large pore bags were placed in Berlese-Tullgren funnels for 7 days (House and Stinner, 1987). Arthropods and earthworms extracted by this procedure were classified to order and family, and specimens have been saved for possible determination to species. Subsequently, the litter from all bags was oven dried and a subsample ashed to correct for soil contamination. Residue decomposition rates were calculated on an ash-free basis.

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** Undergraduate student in the Agronomy Department, also aided by Jill Stengle

Results

Rates of residue decomposition estimated for the two sites are shown in Figures 14 and 15. In general, these data indicate that residue decomposition occurred in all cropping systems with both types of bags, although the time factor was not statistically significant for small pore bags at LAC. The results suggest also that decomposition rate was greater in the large pore bags than in the small pore bags: 65% greater at ARS (October sample) and 98% greater at LAC (September sample). However, the data do not provide evidence for differences in decomposition rate among the three rotations (Hypothesis 1). Note the increases in weight recorded during June for the large pore bags at both sites; this anomaly was the result of soil contamination, which was corrected in processing subsequent samples.

Summaries of animals extracted from the large pore bags are shown in Tables 9 and 10. Although no clear pattern of numbers through time can be discerned from the data, for both sites the greatest numbers were extracted from the August samples. However, the importance of this result is questionable, because the adult stage of what appeared to be one species of fly (Diptera) in the family Cecidomyiidae was responsible for the unusually large numbers observed at both ARS and LAC. This one fly species accounted for 96.6% and 94.2% of the insects extracted during August at ARS and LAC, respectively. We suspect that the larvae of this fly feeds on fungus, and that our sampling happened to catch a mass emergence of the adults. Interestingly, the family Cecidomyiidae also contains the Hessian fly, a prominent pest of wheat.

Statistical analyses were conducted to compare total numbers of animals extracted among rotations within each sample date. For ARS, a significant rotation effect was found for the June and September samples, whereas none of the LAC samples showed statistical significance (note that July and October samples were not available for LAC).

In conclusion, the results of this preliminary study indicated that residue decomposition occurred in all rotations, and that decomposition rate was substantially greater in the large pore residue bags compared with the small pore bags. There was animal activity in the large pore bags in all plots, which probably contributed to the greater decomposition rate observed. There was some evidence for differences in animal activity, but no evidence for differential decomposition rates, among the different cropping systems.

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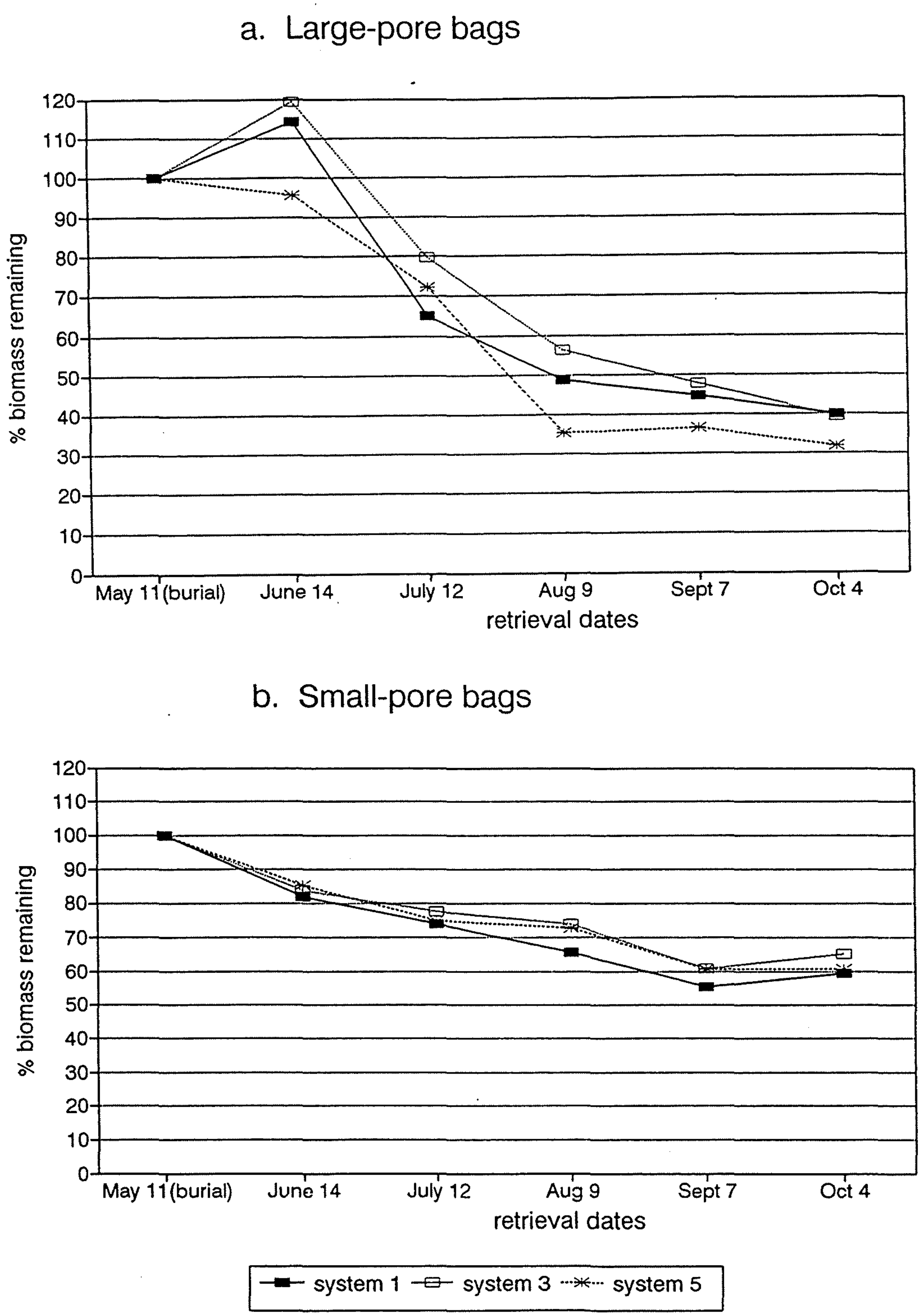
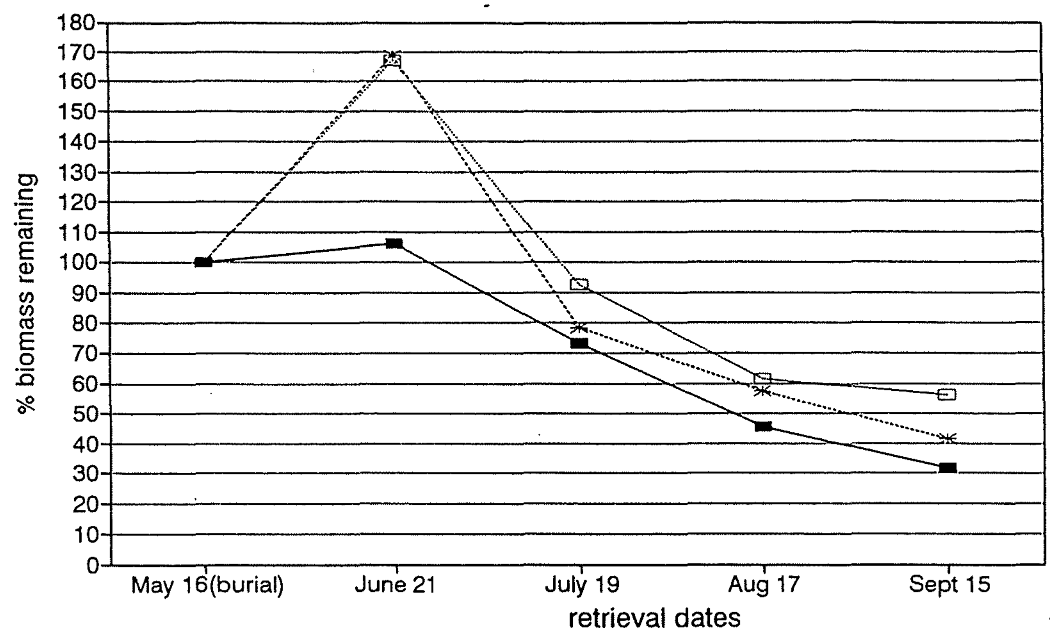


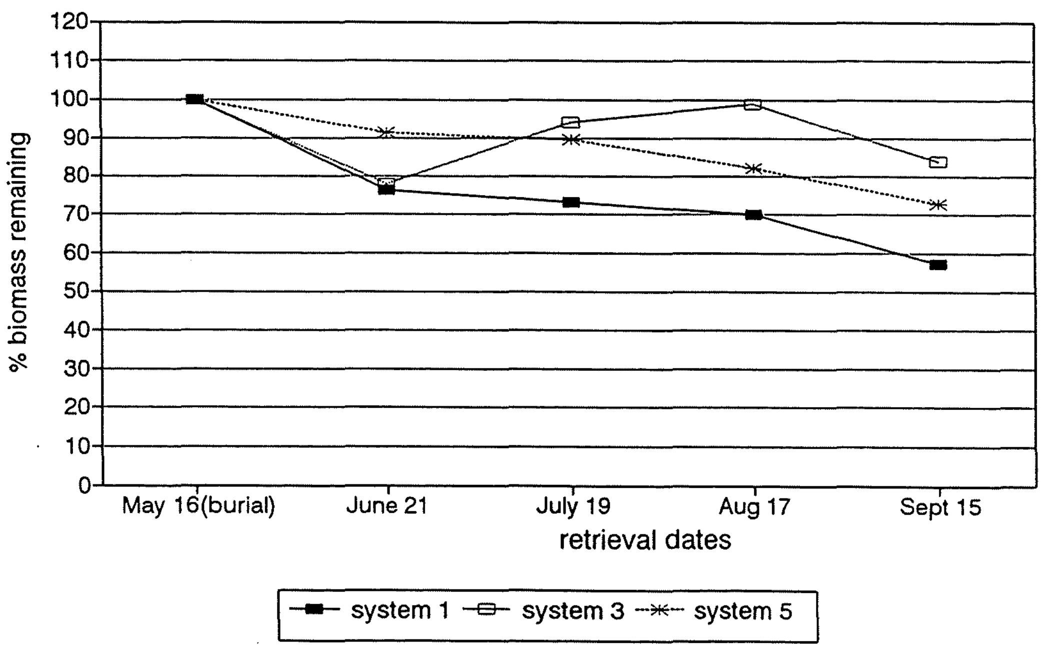
system 1: corn following corn
system 3: soybeans following corn (which followed wheat/red clover)
system 5: oats/alfalfa following corn

Figure 14. Residue decomposition estimates (percent biomass reduction) - ARS 1993

a. Large-pore bags



b. Small-pore bags



system 1: corn following corn
system 3: soybeans following corn (which followed wheat/red clover)
system 5: oats/alfalfa following corn

Figure 15. Residue decomposition estimates (percent biomass reduction) - LAC 1993

Table 9. Mean numbers of animals extracted from large pore bags at the Arlington Agricultural Research Station, 1993.

Month	Rotation	Insects	Other Arthropods	Annelids	Total Animals/Bag
JUNE	C-C	1.5	2.25	0	3.75
	Sb-Wh/RC-C	2.5	8.5	0	11.0
	O/A-A-C	7.25	6.75	0.25	14.25
					(P = 0.011)
JULY	C-C	2.5	0	0.5	3.0
	Sb-Wh/RC-C	0.75	1.25	1.25	3.25
	O/A-A-C	0.75	1.0	0.75	2.5
					(P = 0.90)
AUG.	C-C	14.75	0.25	0	15.0
	Sb-Wh/RC-C	99.25	1.0	0	100.25
	O/A-A-C	11.0	2.5	0	13.5
					(P = 0.19)
SEPT.	C-C	0.75	1.0	0.75	2.5
	Sb-Wh/RC-C	3.0	1.75	0	4.75
	O/A-A-C	4.75	5.25	0.5	10.5
					(P = 0.035)
OCT.	C-C	0.25	0	0.75	1.0
	Sb-Wh/RC-C	0.5	1.0	0.5	2.0
	O/A-A-C	2.75	2.0	0.75	5.5
					(P = 0.13)

Table 10. Mean numbers of animals extracted from large pore bags at the Lakeland Agricultural Complex, 1993.

Month	Rotation	Insects	Other Arthropods	Annelids	Total Animals/Bag
JUNE	C-C	3.0	0.25	0	3.25
	Sb-Wh/RC-C	1.0	0	0.25	1.25
	O/A-A-C	2.25	0	0.25	2.5
					(P = 0.24)
AUG.	C-C	25.25	0.25	0	25.5
	Sb-Wh/RC-C	20.75	1.0	0	21.75
	O/A-A-C	15.0	0	0	15.0
					(P = 0.85)
SEPT.	C-C	0.5	0	0	0.5
	Sb-Wh/RC-C	1.25	0.25	0.5	2.0
	O/A-A-C	0.75	0.5	1.0	2.25
					(P = 0.44)

III. PEST CONTROL STUDIES

A. Field Edge Effects in Potato Leafhopper Populations in Alfalfa

David B. Hogg and Eric Espe*

Introduction

The potato leafhopper (*Empoasca fabae*) is a common pest of alfalfa in Wisconsin. High populations of this insect cause reductions in both quantity and quality of yield and may also reduce stand longevity. Thus good alfalfa management may include monitoring leafhopper population size and implementing control of potentially high populations. The unique natural history of this insect raises issues of sampling and population management. The potato leafhopper does not survive the winter in many alfalfa-producing states, including Wisconsin. Instead, the range of this insect contracts each autumn to an endemic area in the southern states. From there the population expands northward each spring, the insects being carried on southerly winds and weather fronts. They usually reach Wisconsin by early June and are deposited, presumably at random, across the landscape. While the colonization of the northern states is probably accomplished only with heavy mortality, the potato leafhopper's wide host range, which includes over 200 species of plants, minimizes the likelihood of starvation when the insects fall back to the ground at the end of the migration. The insect's short life cycle allows populations to expand quickly.

Despite being able to survive by feeding on a wide variety of vegetation, potato leafhoppers show a strong preference for legumes, alfalfa in particular. Because of the nature of their migration, these insects are thought to be dispersed widely and thinly early in the season. Active by nature, however, they probably redistribute themselves rapidly among the vegetation of a region. Although we know few details of their movement behavior, we assume that they move about in short flights, sampling the vegetation on which they happen to light and moving on after a short time if they find it inadequate. Thus, strongly preferred hosts such as alfalfa may act as population sinks. Furthermore, if the flights of the leafhoppers are sufficiently short, an alfalfa field's edge may accumulate population at a greater rate than its center. Indeed, such edge effects have been noted (Kieckhefer and Medler, 1966). Scouts often sample edges exclusively for detecting early populations (William Lamp, personal communication), and others have observed high populations at alfalfa field edges that border less preferred host vegetation, soybeans, for example (George Hoffman, personal communication). Presumably the mechanism in operation is an enhanced rate of survival of the leafhoppers moving among the less preferred host than of those moving among a nonhost, such as the grasses. The WI Cropping System Trials at the Arlington Field Station has provided a good opportunity for us to determine whether leafhopper populations accumulate at field edges and, in particular, whether adjacent host vegetation enhances this edge effect. This study is part of a larger project, the goal of which is to understand the development of the dispersion pattern of this insect, by modelling and experimentation, in order to refine sampling techniques and predictions of population growth.

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Methods

We chose to sample the seven alfalfa plots that were bordered by soybeans in the 1993 WI Cropping System Trials (plots 105, 107, 114, 203, 205, 308, and 311), taking three samples from each per week with a D-vac suction sampler. The three samples per plot included samples from a host edge, a nonhost edge, and the center. We defined the edge of a plot as the area within 10 m of the plot border. Adjacent host vegetation refers here exclusively to a contiguous soybean plot, and adjacent nonhost vegetation includes the grassy driveways to the north and south of the plots as well as adjacent plots of corn and wheat. We ignored the 3-m strips of fescue that separate a plot from its neighbors to the east and to the west. Thus the host edge sample was taken from the east or the west side of a plot, and the nonhost edge sample was taken from any one of the four sides. We sampled on three dates during the second regrowth cycle (June 24, July 2 and 8) and on six dates during the third regrowth cycle (July 23, 30, August 6, 13, 20, and 27). Each week the number of adult potato leafhoppers in each sample were recorded, and at the end of the season the square-root-transformed data were analyzed by ANOVA under a one-way blocked design with repeated measures. Field (plot) was considered a blocking factor and location (center, host edge, or nonhost edge) was considered the experimental factor.

Results

Average population density per location per date is shown in Table 11, and the analysis of variance table (under an ordinary split-plot design) is shown in Table 12. Notice that the highest population per date is shared nearly evenly among the locations. In the date-by-date analysis of variance under a one-way design with blocking, no date showed a significant edge effect. Likewise, when all the dates were considered together in the analysis of variance under an ordinary split-plot design, no significant edge effect was seen.

Discussion

The results of this study suggest that there is no consistent edge effect in populations of potato leafhoppers in alfalfa. Thus apparently large populations near the borders of a field are to be interpreted as the result of demographic or environmental stochasticity rather than a consequence of this insect's behavior. This interpretation requires an attempt at reconciliation with the published results of Kieckhefer and Medler (1966), which may be the source of currently held views of potato leafhopper dispersion pattern. Kieckhefer and Medler compared sample estimates of population size from the center and margin of an alfalfa field on seven dates during the summer of 1960. Five of the seven showed larger populations at the margin than at the center. Three of those differences were statistically significant at the 5% level, and all three occurred during the same cutting cycle (July and August). Because the same stations were sampled at every date, it seems likely that the test results, particularly those within a cutting cycle, are correlated (the same phenomenon can be seen in the data presented here). Furthermore, because a single alfalfa field was studied, local effects, such as the structure of the landscape, cannot be ruled out as unique causes of what the authors have interpreted as a common phenomenon. The current study addresses these issues briefly. The orientation of the sampled edge (direction from center) and the type of adjacent vegetation varied from plot to plot, and there emerged no clear relationship between population size,

Table 11. Average Population Density per Location per Date

LOC	Date								
	1	2	3	4	5	6	7	8	9
Center	5.71	13.57	11.43	11.00	19.86	15.57	32.86	8.86	3.14
Host	9.43	20.29	14.71	7.00	17.71	13.86	22.14	8.57	4.00
Nonhost	6.43	20.00	13.57	13.14	25.29	21.29	24.14	6.86	3.71

location in plot, and type of adjacent vegetation. Differences from plot to plot and from date to date were greater than differences in location (see the sums of squares in Table 12). Furthermore, the greatest population per plot per time showed no consistent association with a location. Thus, it seems reasonable to conclude that there is no consistent edge effect. One might consequently attribute apparent edge effects to local conditions or to demographic stochasticity.

Table 12. Analysis of Variance Table for Ordinary Split-Plot Design

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	44	255.461114	5.805934	6.69	0.0001
Error	144	124.960826	0.867784		
Corrected Total	188	380.421940			

	R-Square	C.V.	Root MSE		PLH Mean
	0.671520	27.06765	0.93155	.	3.44156

Source	DF	Type I SS	Mean Square	F Value	Pr > F
FIELD	6	32.258693	5.376449		
LOCATION	2	0.957530	0.478765		
FIELD*LOCATION	12	15.394190	1.282849		
DATE	8	188.559763	23.569970	27.16	0.0001
DATE*LOCATION	16	18.290938	1.143184	1.32	0.1941

Tests of Hypotheses using the Type I MS for FIELD*LOCATION as an error term

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LOCATION	2	0.95752979	0.47876489	0.37	0.6962

Reference

Kieckhefer, R. W., and J. T. Medler. 1966. Aggregations of potato leafhopper in alfalfa fields in Wisconsin. *Ann. Entomol. Soc. Amer.* 59 (1) : 180-182.

B. Weed Seedbank and Biomass Observations

Jerry Doll, Tom Mulder and Josh Posner

We continued monitoring the weed seed bank and weed biomass at both the Arlington and Lakeland sites. The methods used were the same as those in previous years and consisted of collecting three samples of ten 3/4-inch diameter soil cores to 6 inches deep in each plot that had been in corn in 1992. Several additional treatments were also sampled to make comparisons on weed seedbank between other treatments. The soil was mixed with an equal volume of pure sand and placed in plastic flats on greenhouse benches. Seedlings were identified and counted when they reached the 2 to 4-leaf stage. Tables 13 and 14 give the weed seed data collected since 1990 for treatments sampled in 1993.

Weed populations in continuous corn (R1) at ARS declined and those at LAC increased even though this system uses conventional herbicide rates and cultivation. The relative proportion of grasses and broadleaves has remained constant at both sites and broadleaves are the dominant weed type. The corn-soybean rotation (R2) uses reduced herbicide levels and cultivation and weed populations have increased 40% at ARS and 10 fold at LAC due to the relatively low population in 1991. The actual population in this rotation at LAC is equivalent to that at ARS. Little change in species composition has occurred at either site. In the low input cash grain system (R3) , only mechanical weeding methods are used and weed populations have increased four and over six fold at the ARS and LAC sites, respectively, as compared to 1991. Compared to 1992, populations and species composition have remained constant

The intensive forage system (R4) has not completed a full cycle yet, but in the low input forage system (R5) weed populations have declined 25% at ARS and nearly doubled at LAC. The proportion of broadleaf weeds has increased at both sites. The weed population at both sites is less than half that for the non-herbicide cash grain system, R3, suggesting that we are more successful in managing weeds mechanically in a forage-based system than in a cash grain system.

Weed seed populations the year after wheat and red clover (trt. 6) increased significantly at both sites compared to 1992. Grasses have increased more at ARS and broadleaves more at LAC during this period.

Weed biomass data (Table 15) show that R1 and R2 were relatively weed-free in 1993. The abundant rains gave excellent herbicide activity of the soil-applied treatments (even at reduced rates) and the foliar sprays were also very effective. In R3, mechanically weeded soybeans were cleaner that corn at both sites. Corn following alfalfa was nearly weed free when herbicides were used (R4) and only slightly weedy when mechanically weeded (R5). This suggests mechanically weeding corn is either easier in a forage-based than a cash grain-based system, the lower weed population in the forage systems makes weeding easier, or the corn is more competitive following alfalfa than red clover. Grass weeds composed most of the biomass in R3 corn at both sites and in R3 soybeans at LAC but not at ARS. The broadleaves and grasses in R5 were in nearly equal ratios at both sites.

In addition to the above activities and data, we treated patches of Canada thistle in R2 corn with clopyralid (Stinger) when thistles were in the bolting to early bud stage. At this time, the corn was less than half as tall as the thistles because no tillage was done prior to planting. The treatment gave immediate results and after cultivation, few if any live Canada thistle plants could be found. These areas will be monitored for thistles in 1994 and similar treatments will be made if/as needed.

Table 13. Weed Seedbank Changes in WICST at the Arlington Agricultural Research Station from 1990-1993.

Trt	System 90-91-92-93	Rotation	Variable	90	91	92	93
1	C-C-C-C	1	seeds/ft^2	448	166	206	266
			% bdlf	86	84	87	86
			% grass	14	16	13	14
2	C-S-C-S	2b	seeds/ft^2	--	144	--	215
			% bdlf	--	70.	--	86
			% grass	--	30	--	14
3	S-C-S-C	2a	seeds/ft^2	429	480	571	--
			% bdlf	75	73	78	--
			% grass	25	27	22	--
5	SW-WR-C-SW	3a	seeds/ft^2	206	459	894	850
			% bdlf	68	80	85	83
			% grass	32	20	15	17
6	C-SW-WR-C	3b	seeds/ft^2	--	703	--	1079
			% bdlf	--	88	--	67
			% grass	--	12	--	33
10	C-C-C-A	4b	seeds/ft^2	--	--	720	269
			% bdlf	--	--	93	88
			% grass	--	--	7	12
11	O/A-A-C-O/A	5a	seeds/ft^2	444	755	692	339
			% bdlf	82	64	91	95
			% grass	18	36	9	5
12	C-O/A-A-C	5b	seeds/ft^2	--	546	--	506
			% bdlf	--	82	--	88
			% grass	--	18	--	12

Table 14. Weed Seedbank Changes in WICST at the Lakeland Agricultural Complex from 1990 - 1993.

Trt	System 90-91-92-93	Rotation	Variable	90	91	92	93
1	C-C-C-C	1	seeds/ft^2	190	68	152	310
			% bdlf	87	72	80	74
			% grass	13	28	20	26
2	C-S-C-S	2b	seeds/ft^2	--	22	--	206
			% bdlf	--	50	--	50
			% grass	--	50	--	50
3	S-C-S-C	2a	seeds/ft^2	193	174	106	--
			% bdlf	28	22	51	--
			% grass	72	78	49	--
5	SW-WR-C-SW	3a	seeds/ft^2	196	328	1117	1288
			% bdlf	42	7	42	44
			% grass	58	93	58	56
6	C-SW-WR-C	3b	seeds/ft^2	--	81	--	272
			% bdlf	--	42	--	63
			% grass	--	53	--	37
10	C-C-C-A	4b	seeds/ft^2	--	--	125	380
			% bdlf	--	--	63	46
			% grass	--	--	37	54
11	O/A-A-C-O/A	5a	seeds/ft^2	307	646	454	587
			% bdlf	28	11	31	46
			% grass	72	89	69	54
12	C-O/A-A-C	5b	seeds/ft^2	--	92	--	112
			% bdlf	--	47	--	88
			% grass	--	53	--	12

Table 15. Weed biomass in the WICST trials at the Arlington Agricultural Research Station and the Lakeland Agricultural Complex for 1992 and 1993.

Trt	System 90-91-92-93	Rotation	Variable	ARS		LAC	
				9293	92	93	
1	C-C-C-C	1	lb/acre	9	2	48	<1
			% bdlf	100	72	77	0
			% grass	0	28	23	100
2	C-S-C-S	2b	lb/acre	27	12	16	19
			% bdlf	82	77	63	90
			% grass	18	33	37	10
3	S-C-S-C	2a	lb/acre	179	4	160	3
			% bdlf	61	48	100	96
			% grass	39	52	0	4
4	C-C-SW-WR	3c	lb/acre	137	-	21	-
			% bdlf	81	-	10	-
			% grass	19	-	0	-
5	SW-WR-C-SW	3a	lb/acre	46	44	21	44
			% bdlf	87	88	37	31
			% grass	13	12	63	69
6	C-SW-WR-C	3b	lb/acre	-	161	-	160
			% bdlf	-	19	-	28
			% grass	-	81	-	72
7	A-A-A-C	4a	lb/acre	-	13	-	18
			% bdlf	-	21	-	76
			% grass	-	79	-	24
11	O/A-A-C-O/A	5a	lb/acre	60	-	186	-
			% bdlf	95	-	58	-
			% grass	5	-	42	-
12	C-O/A-A-A-C	5b	lb/acre	-	46	-	36
			% bdlf	-	50	-	57
			% grass	-	50	-	43

C. The Rotary Hoe - Maximizing its Weed Control Effectiveness

T. A. Mulder and J. L. Posner*

INTRODUCTION

In the corn phases of rotations R3 and R5 of the Wisconsin Integrated Cropping System Trial, mechanical weeding is one of the methods used to reduce purchased inputs. Although weed control is not expected to consistantly be at the same level as if using herbicides, the intent has been to use the best mechanical weed control techniques known. Weed competition early in the corn plant's develpment has the greatest impact on yield. When growing corn without the use of herbicides, the initial after planting weed control method prior to row-cultivation is often rotary hoeing, thus the interest on identifying key factors that improve its ability to uproot weed seedlings without damaging the tender young corn plant. In 1992 an experiment was designed to compare rotary hoe design, speed, weight and spoon wear (Second Report, WICST, 1992). Weeds were abundant and soil condition was poor in this corn following corn situation, but it was clear that spoon wear and number of field passes per hoeing were factors that most affected the rotary hoe's ability to uproot weeds.

A similar trial was designed for 1993 to compare many of the same factors. Since hoe design had no significant effect on weeding ability, only the John Deere[1] rotary hoe was used in 1993. Factors for comparison were: 1) spoon wear (new, slightly worn, very worn), 2) hoe weight (with and without 400 lb added weight), 3) hoe speed (6 and 11 MPH), 4) number of passes (1 and 2), and 5) with and without a late hoeing to replace the first row-cultivation. The 15 ft rotary hoe (6 30-inch rows) was divided into three 5 ft sections, each equipped with either new, slightly worn, or very worn spoons. When making a double pass, the passes were in opposite directions and measurements were only taken from the center 5 ft (2 rows) area, hoed by the slightly worn spoons. The trial was located at the Arlington Agricultural Research Station. Corn was planted May 15 at 32,100 seeds/acre after manure application, moldboard plowing and field tillage following two years of alfalfa. Rotary hoeing dates were May 22, May 28, June 5 and June 12. Row-cultivations were June 23 (6-8 in corn ht) and June 29 (10-16 in corn ht). The treatments with four rotary hoeings only received the second row-cultivation. Measurements taken were weed biomass (at 48-inch corn height), corn height (65 days after planting), corn stand, corn yield, and kernel moisture at harvest.

RESULTS

For all the measurements taken there was no significant difference whether using four rotary hoeings and a late row-cultivation or three hoeings and two cultivations. When the double pass treatments were compared to single pass treatments (using slightly worn spoons), there was no difference due to hoeing speed or hoe weight (Table 16). Weed biomass, corn height, corn stand, and corn yield were all reduced by the second pass. Comparisons of all the treatments with a single pass of the rotary hoe showed aain that hoe weight and speed had no effect on any of the measurements taken. The affect of spoon wear was significant for weed biomass, corn stand and corn yield (Table 17). Weed biomass was greater when using very worn wheels than if using slightly worn or new wheels. Corn stand increased with each increment of greater wheel wear. Corn yield was highest using very worn wheels.

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[1] Deere and Company, Moline, IL 61265.

SUMMARY

Although in-row weed pressure was less than in 1992 (23% of 1992 in-row weed biomass), results were similar, as decreased spoon wear and a double pass improved weed control while reducing corn stand. While weed control was lower, yields were higher with both a single pass and worn wheels which implies that yield was reduced more by low corn stand than by weed competition. If weed pressure was higher yield results may have been reduced. Corn following alfalfa and a late planting date were main reasons for the lower weed pressure in 1993. The competion effect on corn of the weeds that did escape uprooting by the rotary hoe was also reduced by abundant rainfall early in the growing season.

The remaining challenge in rotary hoeing is to increase weed destruction while minimizing damage to the tender youg corn plants. Planting rates should be increased at least 10 percent if controlling weeds mechanically using a rotary hoe with new or slightly worn spoons.

Table 16. Comparison of rotary hoeing with slightly worn spoons with or without added weights, at two speeds, and with a single or double pass.

	Weight			Speed			Passes[1]		
	added[2]		original	6 MPH		11MPH	1		2
Bdlf weeds g/5 ft^2	14.1		12.4	13.2		13.3	19.7		6.9
		NS[3]			NS			7.5	
Corn height inches	47.9		46.4	46.4		47.9	49.1		45.3
		NS			NS			3.2	
Corn pop. plants/a	22100		21300	21200		22200	23400		20000
		NS			NS			1500	
Corn moist. %	38.3		37.5	38.3		37.6	36.7		39.2
		NS			NS			NS	
Corn yield bu/A	104.5		101.0	102.0		103.4	107.1		98.3
		NS			NS			7.1	

[1] A single pass or two passes with the second pass in the opposite direction as the first pass
[2] 400 lbs of weight added
[3] Either not statistically different (NS) or LSD(0.05)

Table 17. Comparison of rotary hoeing with or without added weights, at two speeds, and with three levels of spoon wear.

	Weight		Speed		Spoon wear[1]		
	added[2]	original	6 MPH	11MPH	new	sl.worn	v.worn
Bdlf weeds g/5 ft^2	32.3	25.2	31.1	26.4	14.9	19.7	51.7
	NS[3]		NS			9.7	
Corn height inches	49.5	49.0	49.8	48.7	48.8	49.1	50.0
	NS		NS			NS	
Corn pop. plants/A	24000	22300	23300	22900	20500	23400	25400
	13000		NS			1600	
Corn moist. %	36.4	36.2	35.3	37.3	35.2	36.7	37.0
	NS		NS			NS	
Corn yield bu/A	113.1	109.0	111. 4	110.6	107.2	107.1	118.8
	NS		NS			9.0	

[1] Spoons .75, .63, and .5 inches wide
[2] 400 lbs of weight added
[3] Either not statistically different (NS) or LSD(0.05)

IV. Rotational Grazing of Dairy Heifers: A Low-Input Dairy Rotation in the Wisconsin Integrated Cropping Systems Trial

Laura Paine and Dan Undersander*

Pastures of smooth bromegrass, timothy and red clover were established in 1990 at the Arlington Agricultural Research Station (ARS) and the Lakeland Agricultural Complex (LAC). Fencing and water lines for pastures at both locations were built during the spring of 1992. Figures 16a and b show paddock layout. A grazing trial was established at LAC in 1992. Severe winterkill at ARS, necessitated reseeding of the pasture grasses in 1992, thus grazing of paddocks was not possible until 1993. Red Clover was broadcast seeded over pastures at both sites in early April, 1993 for legume renovation and to fill in areas where the grass stands were thin.

In 1992, pastures at LAC were grazed from 1 May through the first week of October. Two heifers of approximately 425 pounds each (850 pounds/paddock) were grazed on each paddock. One half of three of the paddocks were mowed for hay in early June. The hay was then fed back during July when pasture growth slowed. Average daily gains for the season were slightly higher than desirable at 2.27 pounds/day (target daily gain is 1.8 pounds/day).

Based on 1992 results, several management changes were made at LAC in 1993. Grazing was begun with three heifers per paddock. Due to larger sized animals, the total pounds per paddock was 83% greater at 1554 pounds/paddock. The heifers were put on pasture on 8 May. In an effort to avoid having to make hay during the spring flush of grass growth, paddocks were "flash grazed" for a full cycle. Fences were moved about 50 feet every two days to "top" the grass in the entire paddock. Regular twice-weekly moves were begun on 7 June, with forage allowances based on 3-4% of body weight.

Grazing was begun at ARS on 17 May, 1993. Heifers averaged 398 pounds and two were assigned to each paddock. Fence movement proceeded by the standard three day/four day system according to the original protocol.

Figures 17a and b summarize forage availability at LAC and ARS, respectively. Excessive rainfall during the 1993 growing season enhanced grass growth at both sites. For comparison, LAC 1992 forage growth is shown in Figure 17c. "Flash grazing" appeared to have moderated growth for most of the season, resulting in only a few weeks having high tonnages of available forage. At ARS, movement of the animals to pasture was later than ideal and forage growth got ahead of grazing early in the season. Excess forage was mowed and baled in early June. The hay made from this cutting was of such poor quality that it was not fed to the animals.

Following the first grazing cycle through the paddocks, forage growth was poor at both sites, possibly due to excessive soil moisture, cloudiness, and/or a shortage of nitrogen. Weight gains for this period were lower than desirable (around 1 pound/day), as well, suggesting poor forage quality. To improve pasture condition and increase animal weightgains, the following steps were taken: 1) all paddocks were mowed high to remove _

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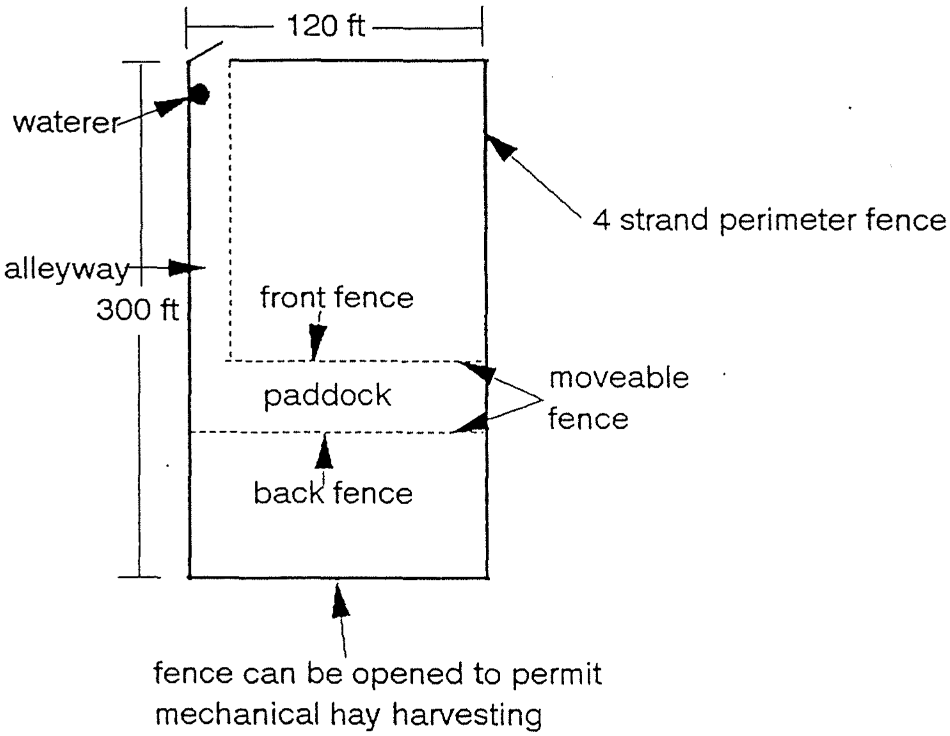
a. Lakeland Agricultural Complex



b. Arlington Research Station

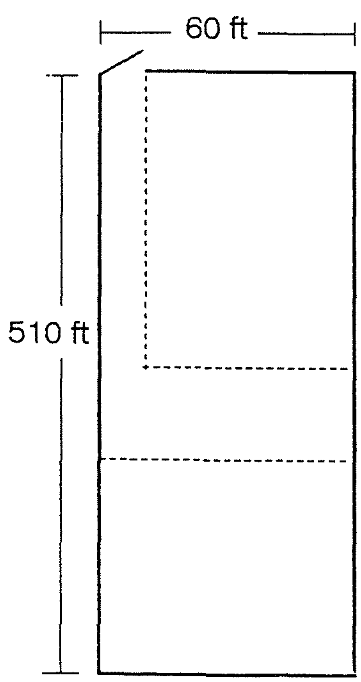


Figure 16. WICST rotational grazing pasture layout

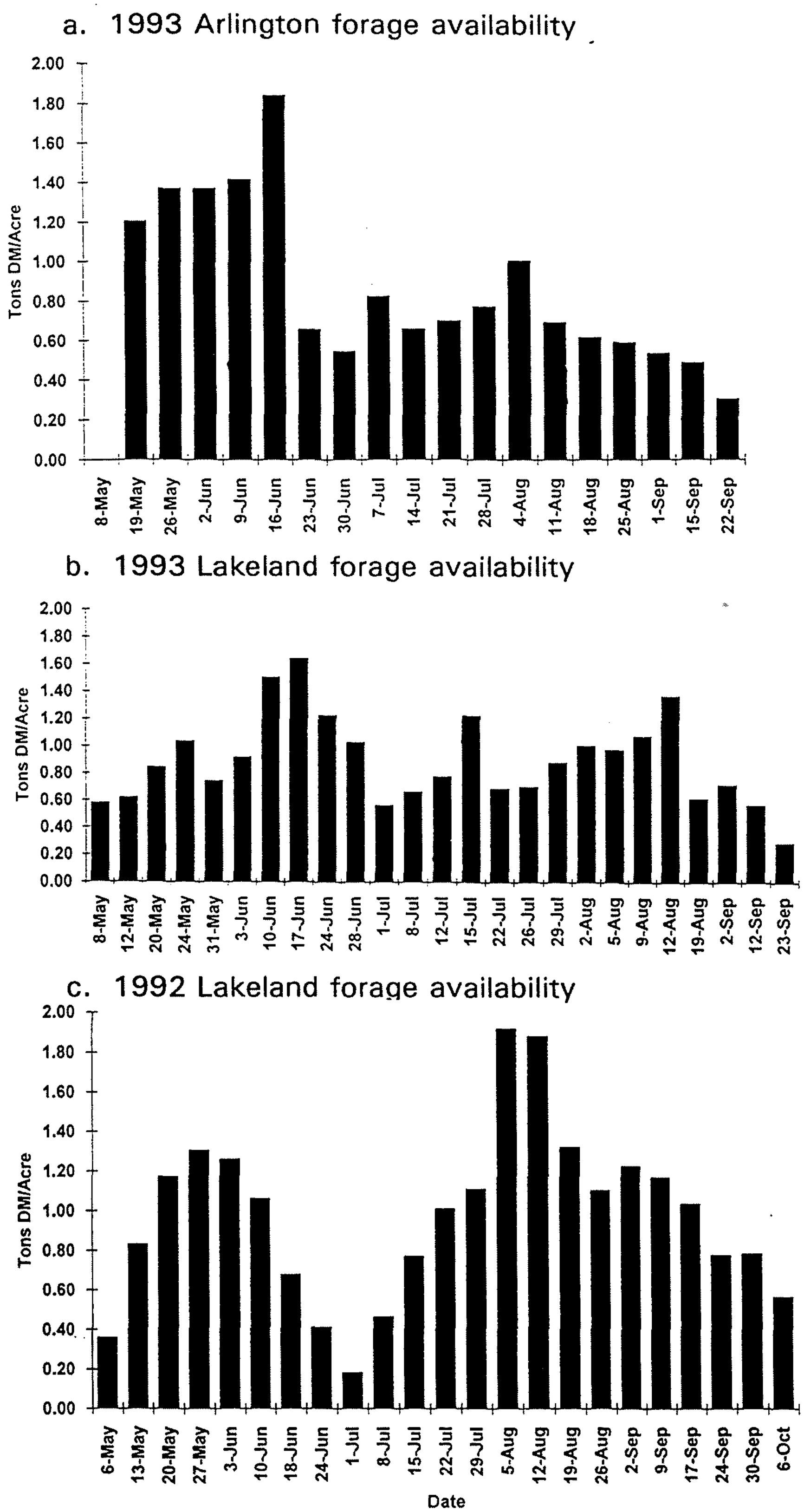


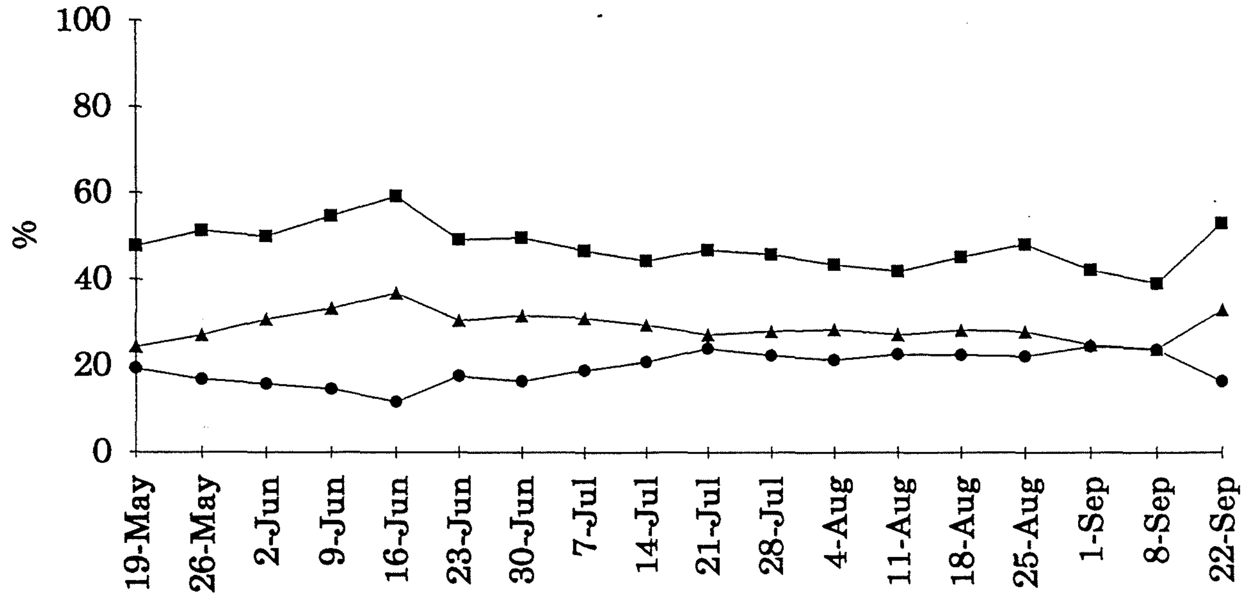
Figure 17. Rotational grazing forage availability at the two WICST sites.

Forage quality, shown in Figures 18a and b, was generally poor at LAC and average at ARS in 1993. Crude protein of the pasture samples averaged 18% at LAC and 21% at ARS (good = 19-20%) Acid detergent fiber (ADF) averaged 36% at LAC and 30% at ARS (good = 30-35%). High neutral detergent fiber (NDF) brought overall quality down at both sites. At LAC, NDF averaged 61%. At ARS, NDF averaged 50% (good < 46%). Figures 19a and b show relative feed values (RFV) for each site for the 1993 growing season. Averages were 95 for LAC and 126 for ARS, both well below the value for prime hay (150). As a comparison, forage quality from the average of three R5 alfalfa harvests at both sites were: 21.7% crude protein, 32.7% ADF, 42.3% NDF, and 142 RFV.

Pasture production was measured by weekly hand cutting, weighing and sample collecting of forage using two randomly tossed 0.5 m^2 squares in each plot prior to movement of cattle into these areas. Distance of fence movement was calculated estimating animal daily dry matter consumption as 3.5 % of body weight. Animal consumption using mean seasonal weights of the animals was compared to pasture forage production for the season. Weight of supplemented hay and grain was subtracted from estimated animal consumption and mechanically harvested forage was subtracted from pasture production. At LAC in 1992, animal consumption was 93.1 % of the estimated forage yield. In 1993 the animal consumption was 97.2 % (LAC) and 75.7% (ARS) of forage yield. This suggests that the 3.5% dry matter consumption estimate was an accurate method for determining fence movement at LAC. At ARS it appears that either animal consumption was less than 3.5% of body weight and/or the addition of the uneaten forage inflated forage production estimates during subsequent sampling.

Animals were removed from the pastures on September 29 at ARS. Animal weight gains at ARS were at acceptable levels (average = 1.76 pounds/day), for a total gain of 688 pounds/acre. Grazing ended at LAC on October 7. Average daily gain at LAC for the animals that remained on pasture all season was 1.64 pounds/day while the animals taken off early gained an average of 1.35 pounds/day. The total weight gain with all three heifers at LAC for the 1993 season was 724 pounds/acre. Animal weight gains are listed in Table 18. Overall performance was fairly good, but costs were greater than 1992 due to grain supplementation and application of nitrogen to pastures.

a. 1993 Arlington Forage Quality



b. 1993 Lakeland Forage Quality

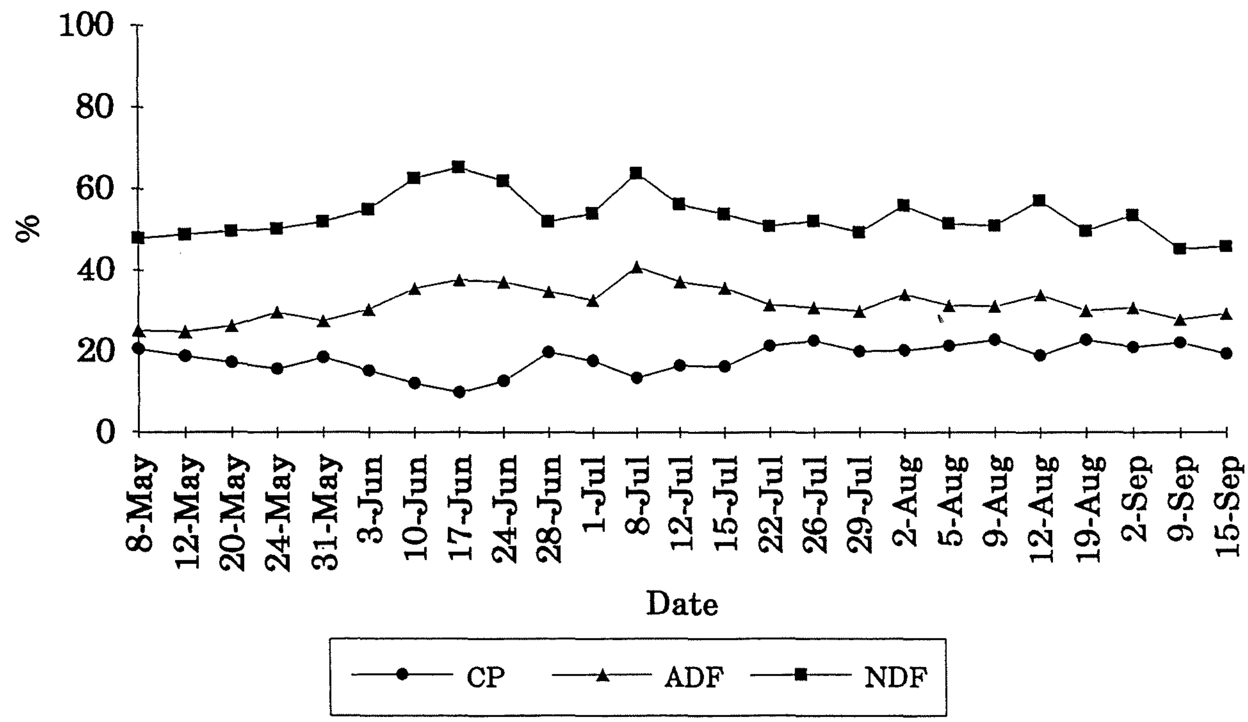


Figure 18 Rotational grazing forage quality at the two WICST sites in 1993.

a. 1993 Arlington Relative Feed Value

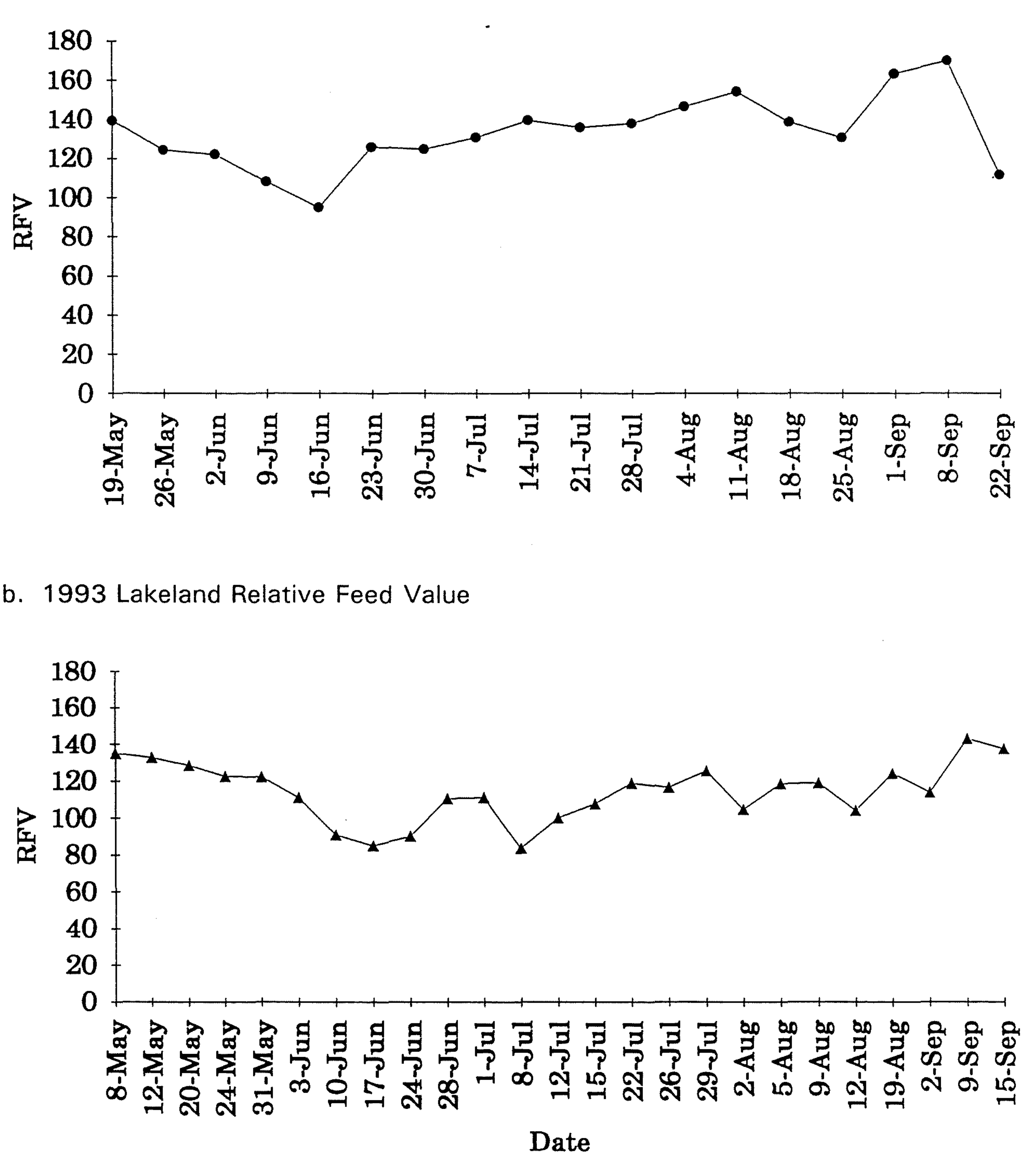


Figure 4. Rotational grazing relative feed value at the two WICST sites in 1993.

Table 18. Average animal weight gains.

Site	Year	Starting Weight	Ending Weight	Gain/ Animal	Gain/ Day	Gain/ Paddock	Gain/ Acre
LAC	1992	425	804	379	2.27	759	914
ARS	1993	398	639	241	1.76	482	688[1]
LAC[2]	1993	518	768	250	1.64	601	724[3]
LAC[4]	1993	476	577	101	1.35		

[1]1366 lb supplemental grain fed per acre.
[2]Data from two animals per paddock that grazed the entire season (152 days).
[3]514 lb supplemental grain and 1028 lb supplemental hay fed per acre.
[4]Data from one animal per paddock that grazed until mid July (75 days).

V. COVER CROP RESEARCH

A. Legume Cover Crops and Fertilizer N Sources for Corn in the Upper-Midwest

J. Stute* and J. Posner**

INTRODUCTION

To be an effective N source for corn, the material (fertilizer or plant) must be able to produce a large pool of mineral N prior to the period of rapid N uptake, beginning at the six-leaf stage (Magdoff, 1991). If the pool is produced too early, the N can potentially be lost via leaching and/or denitrification. If released too late, it will not benefit the crop, and pose a threat to groundwater quality. Recent studies in the Southeastern U S have shown that green manures decompose rapidly (i.e. a 50% loss of biomass within a month) in the warm southern soils and can be a significant source of N to the following corn crop. Regardless of tillage system, most studies have shown that decomposing legumes produce a pulse of available mineral N 2 to 5 weeks after spring cover crop kill (chemical or tillage), followed by a gradual decline of available N, corresponding to crop uptake, over the growing season. In these cases, the rapid release of mineral N resulted in a pool of available N, prior to the critical period indicated by Magdoff (1991).

Not all reports however, suggest that green manures are a good source of N for corn. In Kentucky, Huntington *et al.* (1985), found that the majority of cover crop N became available after corn silking, resulting in high levels of mineral N late in the season and ultimately, poor synchronization between N availability and corn demand in a NT system. Continued mineralization, late in the season, may represent a source of potentially leachable nitrate-N. Groffman *et al.* (1987) found that late season mineral N levels were higher following a cover crop than following N fertilizer. Despite the higher levels of mineral N late in the season, they reported that leaching losses were insignificant.

These conflicts in findings require the further investigation of the synchrony between cover crop N availability and corn demand if cover crops are to be used as an effective, yet environmentally sound N source. Also, to date no field studies have been reported in the North Central States that have monitored the dynamics of green manure breakdown. The goal of this study was to determine the efficiency and environmental soundness of using legume cover crops as a N source for corn by determining the synchrony between N release and the uptake requirements of corn. The objectives of this study were to:

1. Monitor legume decomposition and the rate of N release, both over-winter and during the growing season, comparing red clover and hairy vetch.

2. Compare the cover crops to a control (0 N) and the recommended rate of fertilizer N for:
   - soil mineral N levels throughout the growing season
   - whole plant N uptake throughout the growing season
   - corn grain yield
   - post-harvest, potentially leachable soil NO_3-N

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** Professor, Dept. of Agronomy, Univ. of Wisconsin, Madison.

MATERIALS AND METHODS

A field study was conducted in 1991 and 1992 at the University of Wisconsin Experimental Station near Arlington, WI on a Plano silt loam soil. The experimental design was a randomized complete block with three replicates. Individual plot size was 15 x 30 ft. Treatments consisted of corn following:

1. red clover, companion seeded with oat the previous year
2. hairy vetch, seeded after oat harvest the previous year
3. oat / no cover the previous year, with no added N in the corn phase
4. oat / no cover the previous year, with 160 lb/acre added N in the corn phase

Corn was planted at a rate of 27 900 kernals / acre in 30 inch rows one day after tillage. Tillage consisted of spring chisel plowing which also served to kill the cover crops, disking, and field cultivation. Weed control consisted of a preplant incorporated application of standard herbicides and cultivation. Ammonium nitrate was broadcast at planting in the N fertilizer treatment.

Legume decomposition and the synchrony between N availability and corn uptake was measured using residue bags and intensive plant and soil sampling. Over-winter decomposition of the legume herbage was estimated by placing herbage in nylon residue bags, placing the bags on the soil surface and recovering them the next spring. Samples of the material were analyzed for total DM, N and ash content. Analysis of DM and N disappearance was made on an ash-free basis to minimize the effects of soil contamination (Wilson and Hargrove, 1986).

Legume decomposition over the course of the growing season was measured by burying legume material in residue bags in the spring and recovering the bags at two week intervals throughout the growing season. The residue bags were buried following tillage, in a manner approximating residue distribution in the tillage zone. Two bags were placed together at random sampling stations (six stations in each plot, one station for each sampling date). Both bags at a given station were recovered at the same sampling date. The bags were recovered at 2,4,6,8, 10, and 16 weeks after placement and the recovered material was analyzed as previously described.

Plant available soil N was measured at planting, and along with corn N uptake, was measured throughout the growing season, with the same sampling schedule used for residue bag recovery. Inorganic soil N (NH_4^+ and NO_3^-) was measured to a depth of three feet in all treatments. Samples were taken in three on-foot increments and analyzed for total mineral N using the steam distillation methods of Bremner (1965). Whole plant corn samples were taken by harvesting ten random plants at ground level. Samples were analyzed for DM and N content. Corn grain yields were estimated by harvesting two undisturbed rows with a plot combine. Soil nitrate-N was measured to a depth of three feet in one-foot increments, following corn harvest in the fall.

Data were subject to analysis of variance procedures (SAS Institute, Inc., 1982) to detect significant main effects and interactions. Treatment means were separated using a least significant difference (LSD) test at the 5% level of probability at sampling dates where significant treatment differences occurred. Orthogonal contrasts were used to directly compare cover crop and fertilizer (160 lb N/acre) and cover crop and control (0 N) for all variables.

RESULTS

Over winter Decomposition

The year and treatment main effects for over winter decomposition were significant. Hairy vetch herbage released more of it's N than red clover: 44 vs. 7% respectively over the 1990-1991 winter; and 57 vs. 24% respectively over the 1991-1991 winter.

Growing Season Decomposition

Despite very different growing season conditions, the effect of year was not significant and N release (Figure 20) was nearly identical in both years. In general, N release from hairy vetch residues was initially more rapid than from red clover (46 vs. 24% respectively, averaged over years) by the first sampling date, but rates were similar after the 4 week sampling date, where both treatments had released 50% of their N. Beyond the four week sampling date, decomposition rates slowed dramatically and very little N was released beyond the tenth week.

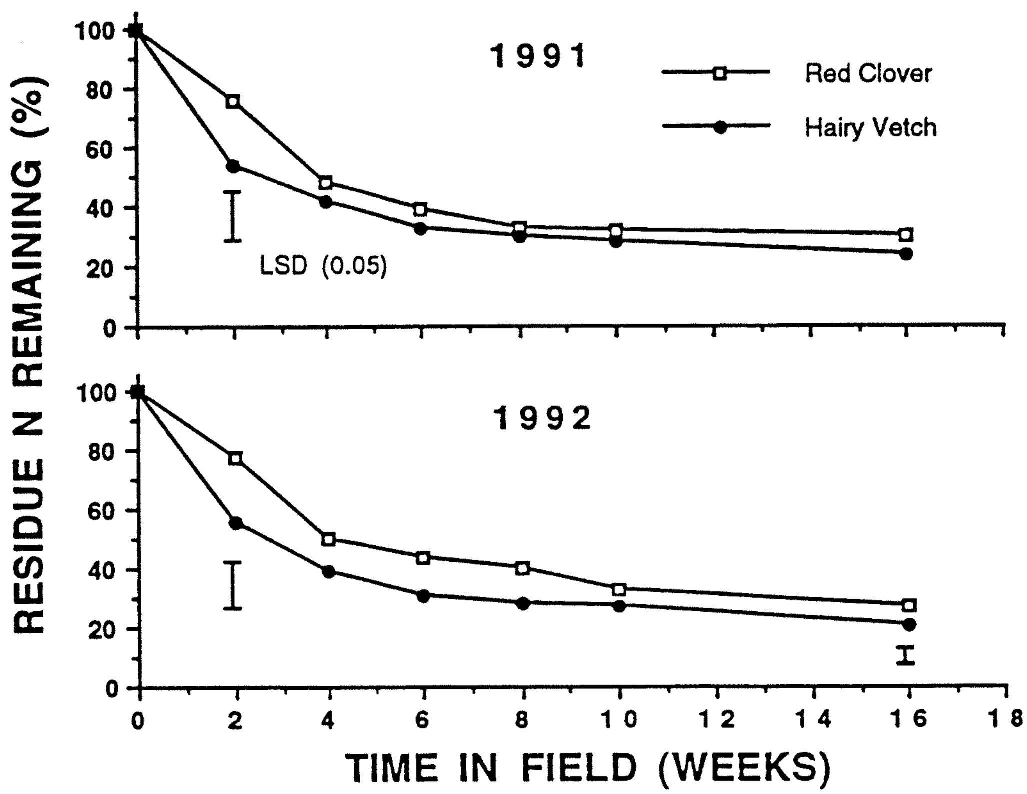

Figure 20. Legume residue N disappearance as affected by species throughout the 1991 and 1992 growing seasons.

Soil Mineral N

In 1991, all significant treatment differences occurred in the top foot (Figure 21). In general, treatments showed an increase in mineral N concentration, a plateau of varying duration, followed by rapid decline. Mineral N concentrations following hairy vetch reached their maximum 2 weeks after planting, while mineral N concentrations following red clover reached their maximum four weeks after planting. Mineral N concentrations produced with fertilizer also reached their maximum four weeks after planting, despite being applied in a 100% mineral form. Presumably, mineralization of native SOM (as measured with the no N treatment) contributed to the total mineral N concentration of this, as well as the other treatments. At four weeks after planting, N concentration in the top foot following fertilizer was significantly higher than concentrations following either of the legumes. However, these concentrations decreased dramatically from four to six weeks, with a corresponding increase in mineral N concentration in the second foot, indicating downward movement of the N. Mineral N concentrations following all treatments were equivalent at week ten, and similar at week sixteen.

In 1992 (Figure 22), significant treatment differences occurred at all three sampling depths. Fertilizer N produced a large increase in mineral N concentration within two weeks of planting, at all three depths and resulted in significant treatment differences in the second and third foot depths. These concentrations decreased at all depths between weeks two and four, resulting in no significant differences between treatments until week ten. In the top foot, treatments exhibited the same trends as in 1991; a general increase in concentration (with some fluctuation) to week eight, followed by declines to the end of the growing season, where all treatments were similar at all three depths.

Corn N Uptake

The main effects of year and treatment for growing season N uptake (Figure 23) were significant. In 1991, adequate soil moisture and high temperatures resulted in rapid growth and N uptake, beginning six weeks after planting. Nitrogen uptake following the two legumes and fertilizer were closely grouped and significantly higher than the no N treatment at weeks six, ten (corresponding with silking) and sixteen (corresponding to physiological maturity) after planting. In 1992, inadequate soil moisture until mid-July and low temperatures resulted in delayed growth and a different uptake pattern. Nitrogen uptake to week eight was slow, approximately 50% of that in 1991, and then appeared to be constant (by treatment) to week sixteen. At silking, total uptake following red clover was significantly less than following hairy vetch or fertilizer, which showed no symptoms of N deficiency. At maturity, treatments did not differ significantly, despite a wide range in total uptake between treatments.

Grain Yields

Despite dissimilar growing seasons, grain yields (Table 19) remained fairly constant. Orthogonal contrasts revealed that grain yields of corn following both legumes were significantly different from the no N treatment, while not significantly different from the fertilizer treatment.

Post Harvest Profile Nitrate

In 1991, treatments did not differ significantly at any depth (Table 20), while in 1992, significant treatment differences occurred at the second and third foot depths and profile totals. Nitrate levels following N fertilizer were significantly higher at these depths (and total) than following the other treatments.

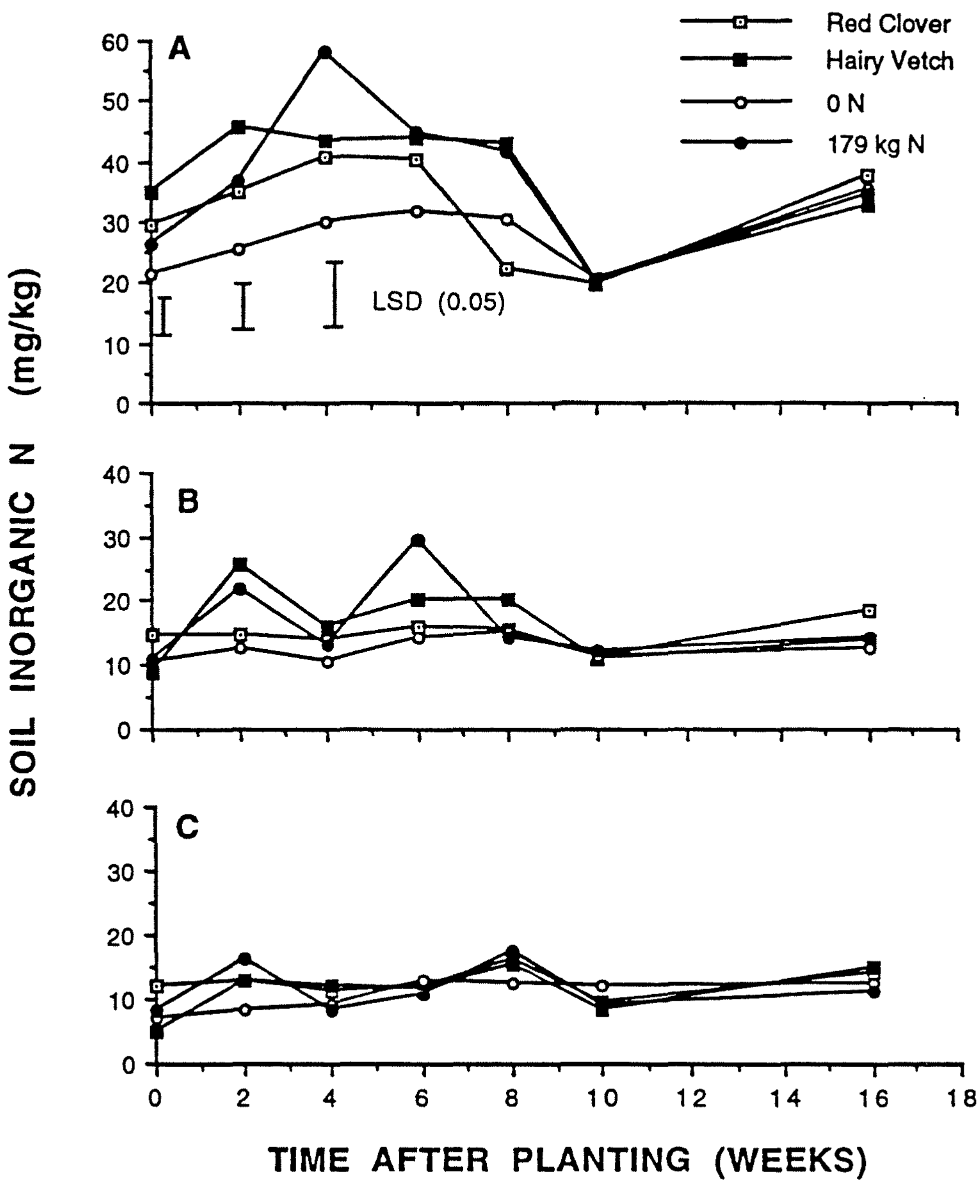

Figure 21. Total soil inorganic N (ammonium and nitrate) at three depths: (A) 0-1 ft; (B) 1-2 ft; (C) 2-3 ft as affected by N source throughout the 1991 growing season. Vertical bars represent the least significant difference (LSD) at sampling dates where significant treatment differences occurred.

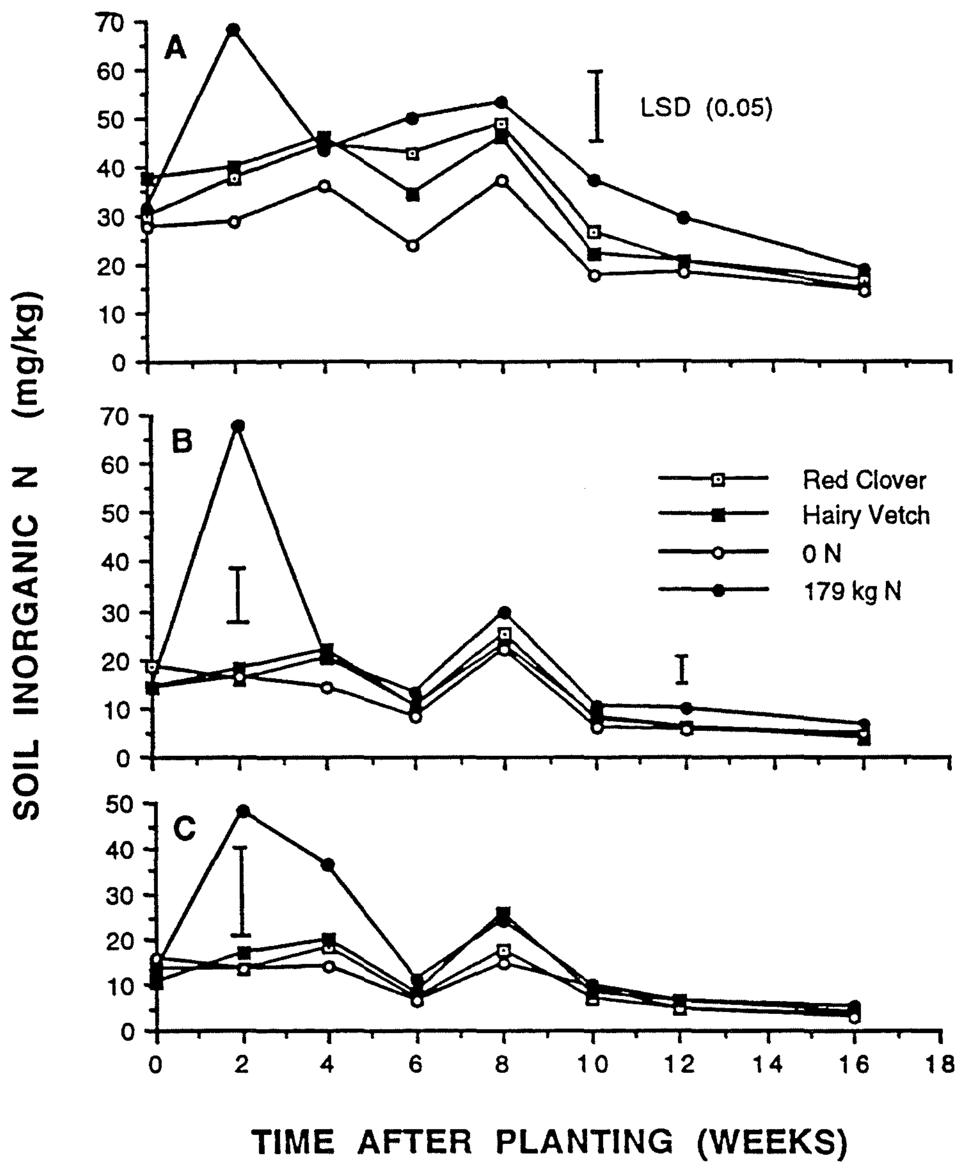

Figure 22. Total soil inorganic N (ammonium and nitrate) at three depths: (A) 0-1 ft; (B) 1-2 ft; (C) 2-3 ft as affected by N source throughout the 1992 growing season. Vertical bars represent the least significant difference (LSD) at sampling dates where significant treatment differences occurred.

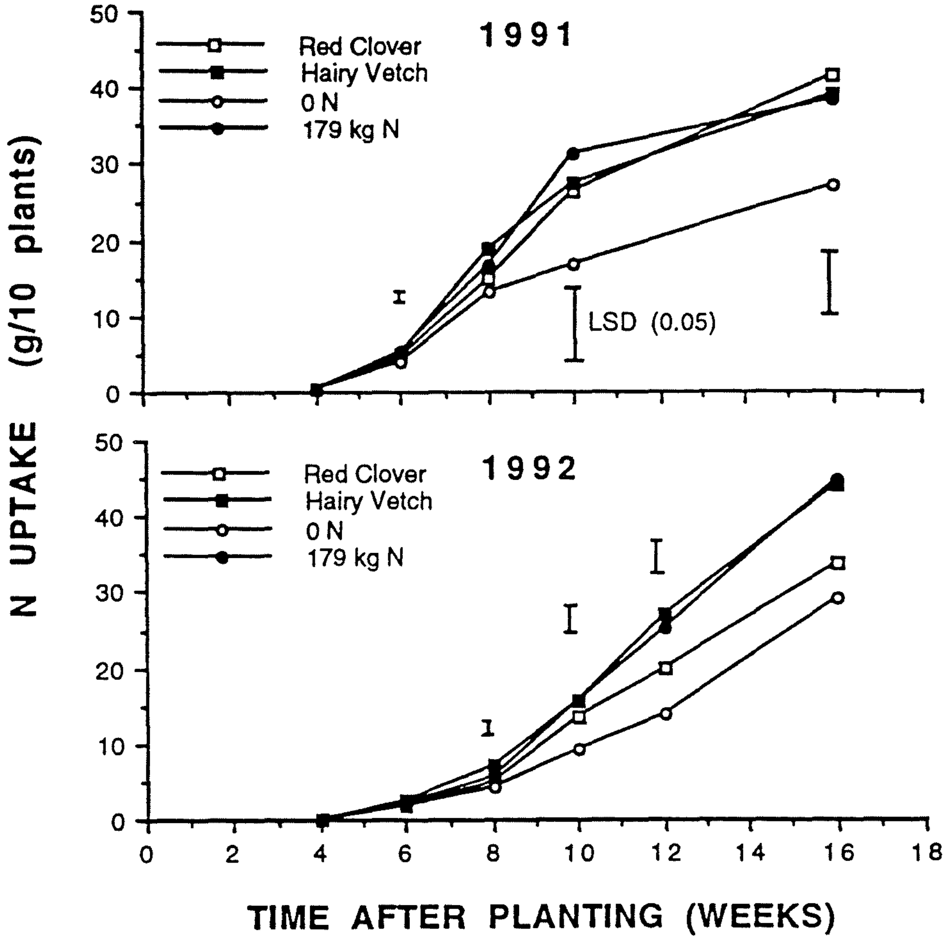

Figure 23. Corn whole plant N uptake as affected by N source throughout the 1991 and 1992 growing seasons. Vertical bars represent the least significant difference (LSD) at sampling dates where significant treatment differences occurred.

DISCUSSION

For legumes to be an effective, environmentally sound N source, there must be a synchrony between residue N release and corn uptake requirements. If legume decomposition is too rapid, the resultant soil mineral N could be lost from the system by denitrification or leaching before corn requires it. Conversely, if decomposition is too slow, the resultant soil mineral N will not be available to meet the uptake demands and poses a threat to groundwater. An effective N source must produce a large pool of mineral N just before the period of rapid N uptake by corn (Magdoff, 1991).

Table 19. Corn grain yield as affected by N source in 1991 and 1992.

N Source	1991	1992
	Bu/acre[†]	
Red Clover	172	170
Hairy Vetch	188	178
0 N	143	141
160 lb Fertilizer N	178	168
LSD (0.05)	21	26
Contrasts:		
Legume vs. 0 N	**	*
Legume vs. 160 N	NS	NS
Red Clover vs. Hairy Vetch	NS	NS

[†]corn grain yields adjusted to a standard moisture content of 15 %.
*, ** significant at the 0.05 and 0.01 level of probability respectively.
NS not significant.

Table 20. Post harvest soil profile nitrate-N as affected by N source in 1991 and 1992.

	Depth (ft)			
N Source	0-1	1-2	2-3	Total
		lb/acre		
		1991		
Red Clover	29	18	14	61
Hairy Vetch	40	32	15	87
0 N	27	13	6	46
160 lb Fertilizer N	32	34	15	81
LSD (0.05)	NS	NS	NS	NS
Contrasts:				
Legume vs. 0 N	NS	NS	NS	NS
Legume vs. 160 N	NS	NS	NS	NS
R. Clover vs. H. Vetch	NS	NS	NS	NS
		1992		
Red Clover	35	14	13	62
Hairy Vetch	39	16	11	66
0 N	26	9	8	43
160 lb Fertilizer N	58	39	21	121
LSD (0.05)	NS	19	7	48
Contrasts:				
Legume vs. 0 N	NS	NS	NS	NS
Legume vs. 160 N	NS	**	**	*
R. Clover vs. H. Vetch	NS	NS	NS	NS

*,** significant at the 0.05 and 0.01 level of probability respectively. NS not significant.

The results of this study indicate that legume cover crops can be an effective N source for corn in the upper-Midwest. Legume decomposition was rapid; incorporated residues lost 50% of their N within four weeks of burial, and the temporal pattern of N release was similar to the results of Wilson and Hargrove (1986). Little additional N was released beyond ten weeks (corresponding to corn silking) indicating that decomposition ceased at a point when corn typically would have taken up most of its total N (Hanway, 1963).

Rapid decomposition and N release resulted in the development of a "pool" of available N, before the onset of rapid uptake. In general, pool development following the legumes was slower than the fertilizer treatment, which is expected as the fertilizer N was applied totally in an inorganic form. Unlike fertilizer, legume decomposition did not produce individual treatment "spikes", rather they showed a buildup of mineral N from steady release, with little apparent downward movement through the profile. Like fertilizer, mineral N levels following the legumes decreased fairly rapidly, once rapid N uptake began, and were similar to the background (0 N) levels at physiological maturity. These results, including the temporal trends are in general agreement with the results reported by Ebelhar *et al.*, (1984) and Sarrantonio and Scott (1988) but conflict with those of Groffman *et al.* (1987) who found that late season mineral N levels to be higher following a legume than with fertilizer.

Whole plant N content at physiological maturity following the legumes was almost identical to that produced with fertilizer in one year of the study, while statistically similar in the other. Corn grain yields following the legumes were nearly identical to those produced with fertilizer. These two results, when combined, would indicate that in addition to supplying N in a timely fashion, the legumes released it in sufficient amounts for this soil type.

Finally, post harvest levels of potentially leachable nitrate-N were similar to or significantly less following the legumes than with fertilizer. This leads us to the conclusion that in addition to being an effective N source, legume cover crops pose no greater a threat to ground water quality than N fertilizer applied at currently recommended rates.

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B. Legume Cover Crops as a Nitrogen Source for Corn in an Oat-Corn Rotation

J.K. Stute and J.L. Posner*

Research Question

Use of legume cover crops as green manures is one potential way to reduce the amount of N fertilizer used in corn (grain) production. Little information is available on the potential role of legume cover crops in cash grain systems of the Midwest. Most recent cover crop research has been conducted in the southern U S, where the growing season is longer and the use of winter annual cover crops is possible. The objectives of this study were to identify the most productive legume species and seeding method to be used with oat, to measure the effect of these legumes on the grain yield of a subsequent corn crop, and to evaluate the economic viability of oat/legume-corn rotations relative to continuous corn grown with fertilizer N.

Literature Summary

Seeding year productivity of forage legumes grown in annual rotation with corn has been evaluated to a limited extent in the upper Midwest. However, this work has focused on legumes used as annual forages, managed for maximum forage production in the seeding year where only the regrowth following final harvest is available as an N source for corn. In addition to providing only minimal material for plowdown, this approach is also unsatisfactory because the removal of any herbage in the seeding year may result in a net soil N deficit. A few studies have evaluated unharvested legumes as a N source for a subsequent crop, but have used a target crop other than corn , evaluated only one response year, or measured the fertilizer replacement value without analyzing the overall rotation within an economic framework.

Study Description

The study was conducted from 1989 to 1993 at the University of Wisconsin Agricultural Research Station near Arlington, WI on a Plano silt loam (Fine-silty, mixed, mesic Typic Argiudoll). The effect of forage legumes used as green manures for a subsequent corn crop was evaluated in a two year oat/legume - corn rotation. Five legumes: nondormant alfalfa; dormant alfalfa; medium red clover; yellow sweetclover; and hairy vetch were both companion seeded with oat and seeded after oat harvest (sequentially seeded). Total (tops and roots) N accumulation was measured at the end of the seeding year. Corn was grown following the oat/legume combinations with no added N, following oat with no legume and six rates (0-200 lb/acre) of added N, and following corn with the same rates of added N. Grain yield was used to determine the effect of legumes on the subsequent corn crop. An economic analysis was conducted on the basis of gross margin (gross return - variable cost), using costs for all inputs used and crop yields. This report represents an update and summary of last years report.

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* J.K. Stute, formerly a graduate student, is now a UW-Extension Agent for Racine and Kenosha Counties. J.L. Posner is a professor of Agronomy, Dept. of Agronomy, Univ. of Wisconsin, Madison. The full manuscript for this study has been submitted to the Journal of Production Agriculture.

APPLIED QUESTIONS

What is the best legume / oat system to use for corn?

Medium red clover companion seeded with oat, and hairy vetch seeded after oat harvest were the most productive legumes as indicated by seeding year N yield (Table 21). Mean N yield of these two legumes was 118 lb/acre. Nitrogen yield of other legumes was limited by: insect damage (companion seeded alfalfa); mechanical damage during oat harvest and slow subsequent regrowth (companion seeded sweetclover and hairy vetch); and except for hairy vetch, the short growing season for the sequentially seeded legumes. The effect of establishment method, companion vs. sequentially seeding on legume N accumulation was significant in all years, but inconsistent.

Legumes had a significant positive effect on corn yield every year, and were 116% of yield of the no legume-no fertilizer control when averaged over years (Table 21). Mean grain yield following the most productive legumes, companion seeded red clover and sequentially seeded hairy vetch were 123% of the no legume/no fertilizer control. There was no clear relationship between legume N accumulation and subsequent corn yield (Table 21). On medium-textured soils with higher organic matter content, crop rotation may contribute substantially to the positive effect of a previous legume on corn yield, masking N effects.

How do productive oat + cover crop-corn rotations compare economically to continuous corn rotations using N fertilizer?

When averaged over the rotation, both oat/ companion seeded red clover-corn and oat/ sequentially seeded hairy vetch-corn rotations performed similarly to oat/ no legume-corn and continuous corn rotations grown with the recommended rate of N (Table 22). The oat-corn rotation using red clover produced a greater gross margin than hairy vetch because of the lower seeding costs, both seed and the additional field operations required for sequential seeding. The oat/companion seeded red clover rotation also produced a slightly greater gross margin than the oat/ no legume-corn rotation using fertilizer N. Because the only difference in inputs between these two rotations were red clover seed vs. N fertilizer, it appears that clover was a competitive substitute for fertilizer in this rotation. Gross margins of the legume rotations including red clover and hairy vetch were similar to that of continuous corn grown with 160 lb N/acre. Lower gross returns for legume rotations were offset by lower variable costs, resulting in similar gross margins. The competitive economic performance of the legume containing rotations compared to the nonlegume rotation and continuous corn should make this low input alternative attractive to many producers.

Table 21. Mean legume seeding year N accumulation and subsequent corn grain yield with no added N fertilizer.

Legume/ Establishment method	Legume N Accumulation	Corn Grain Yield
	lb/acre†	bu/acre††
Companion Seeded		
Nondormant alfalfa	56	156
Dormant alfalfa	49	141
Red clover	128	163
Sweetclover	47	148
Hairy vetch	79	161
Sequentially Seeded		
Nondormant alfalfa	47	163
Dormant alfalfa	42	153
Red clover	50	149
Sweetclover	67	154
Hairy vetch	108	167
No legume/ no N fertilizer		134
Legume Mean	67	156
Contrasts:		
Companion vs. sequentially seeded	*	
Legume vs. no legume		**

*,** Significant at the 0.05 and 0.01 level of probability. † Includes tops and roots ††15% moisture.

Table 22. Summary of mean economic performance of two selected oat / cover crop rotations including red clover and hairy vetch and continuous corn from 1989 to 1993.

Item††		Rotation† O+RC-C	O+HV-C	O-C	C-C
A. Variable Costs		$/acre			
Oat Phase		47.58	67.36	28.28	
Corn Phase		135.21	140.35	156.42	162.93
	Rotation mean:	91.40	103.86	92.35	162.93
B. Gross Returns					
Oat Phase		144.45	135.09	135.09	
Corn Phase		370.01	379.09	374.55	329.15
	Rotation mean:	257.23	257.09	254.82	329.15
C. Gross Margin §		165.83	153.20	162.47	166.22

† Rotations: O+RC-C, oat/companion seeded red clover-corn; O+HV-C, oat/sequentially seeded hairy vetch-corn; O-C, oat/ nolegume-corn; C-C, continuous corn. †† Prices used in analysis: corn, $2.27/bu; oat, $1.17/bu; straw, $45/ton; N fertilizer, $0.12/lb N. § Gross margins = mean gross return - mean variable costs.

C. Corn Fertilizer Rates Following a Green Manure Plowdown

E.B. Mallory*, J.K. Stute** and J.L. Posner***

Introduction

Previous cover crop studies in southeastern Wisconsin have shown that red clover and hairy vetch, incorporated into an oat-corn rotation, both have the potential to produce up to 150 lb/acre of nitrogen by the fall of the seeding year (Stute et al., 1993). While corn following these green manures benefits greatly from their nitrogen contribution, it is possible that supplemental fertilizer nitrogen may be needed to obtain optimum yields. The objective of this study was to compare nitrogen fertilizer response curves of corn in rotation following red clover and hairy vetch to continuous corn.

Materials and Methods

The trial, located at the Lakeland Agricultural Complex, used a split plot arrangement of treatments within a randomized complete block design to compare three different rotations (main plots) at six different nitrogen fertilizer rates (subplots). The treatments, listed in Table 23, were replicated four times.

During phase 1 of the rotation, red clover was seeded simultaneously with the oats whereas, hairy vetch was planted following oat harvest with a no-till drill. Both of the legumes were inoculated with the appropriate *Rhizobium* spp. at seeding. Cover crop biomass yields were measured following a killing frost. Herbage samples were harvested from two random half meter square areas, one inch above the soil surface and were separated into legume and weed fractions. Root and crown samples were taken by undercutting the cover crops to a depth of 10 inches, and removing the roots from a half meter square area. Biomass samples were dried at 140°F for 3 days, weighed, ground to pass through a 1mm screen and analyzed for N content using a Leco N determinator.

Corn (phase 2) was planted following chisel plowing and two passes with a soil finisher, operations which both killed the cover crop and incorporated much of the residue. Weed control for the rotation corn consisted of herbicides (Dual at 1.3 pt/acre and Buctril at 1 pt/acre) and cultivation. Continuous corn plots received Extrazine II DF (2.5 lb/acre), Confidence (2 qts./acre) and cultivation for weed control and an rootworm insecticide (Counter, 11 lb/acre). Nitrogen fertilizer (ammonium nitrate) was broadcast at planting at rates of 0, 40, 80, 120, 160 and 200 lb N/acre. Corn grain was harvested from two 20-foot rows using a plot combine, and yields were corrected to 15% moisture.

Results and Discussion

Nitrogen yields of companion-seeded red clover were consistently high, 105 lb N/acre on average, and were three to four times greater than those of hairy vetch (Table 24). The vetch, planted after oat harvest in late July to mid-August, did not establish well in any of the three years due to limited mid-summer precipitation.

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** UW-Extension Agent, Racine and Kenosha Counties.
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Table 23. Corn fertilizer rates following a green manure plowdown.

	Treatments			
	Phase 1		Phase 2	
Rotation	Mainplot	Subplot	Mainplot	Subplot
I	Corn	0 N	Corn	0 N
		40 N		40 N
		80 N		80 N
		120 N		120 N
		160 N		160 N
		200 N		200 N
II	Oats/Companion-seeded Red Clover		Corn	0 N
				40 N
				80 N
				120 N
				160 N
				200 N
III	Oats/Sequentially seeded Hairy Vetch		Corn	0 N
				40 N
				80 N
				120 N
				160 N
				200 N

Table 24. Total (tops and roots) nitrogen yields of cover crops treatments in the seeding year.

Cover crop Treatment	1991	1992	1993
Companion-seeded Red Clover	101.4	95.4	117.1
Sequentially seeded Hairy Vetch	28.5	22.3	†

† Treatment was not sampled in 1993.

Corn following the red clover yielded higher than continuous corn, in both years, over the full range of nitrogen fertilizer rates (Fig. 24). While nitrogen had a positive effect on both rotated and continuous corn yields, corn following red clover yielded, on average, 59 bu/acre more than the continuous corn in 1992 and 22 bu/acre more in 1993. Continuous corn yielded poorly in 1992 due to herbicide failure and corn rootworm damage. Nonetheless, it appears that corn following red clover benefitted from, what is most likely, a combination of nitrogen and "rotation" effects.

Results from 1992 suggest that the rotation effect was the more important of the two effects. Hairy vetch biomass nitrogen yields were a fraction of those of red clover in 1991 (Table 24) yet corn following the vetch performed similarly to corn following the red clover (Fig. 24, 1992). Both yielded, on average, 63 bu/acre more than the non-rotated corn, indicating that rotating had a large effect on corn yields regardless of cover crop nitrogen contribution. In contrast, corn following hairy vetch yielded similarly to continuous corn in 1993, indicating that there was little benefit from the rotation alone.

This trial was redesigned after the 1993 season in order to more accurately examine the relative importance of the nitrogen and rotation effects of green manures. Beginning in 1994, the hairy vetch was removed from the trial so that the three main plots are: continuous corn, oat-corn, and oat/red clover-corn.

Reference

Stute, J.K., J.L. Posner and E.B. Mallory. 1993. Cover crop research of the Wisconsin Integrated Cropping Systems Trial. *In* The Wisconsin Integrated Cropping Systems Trial - Second Report.

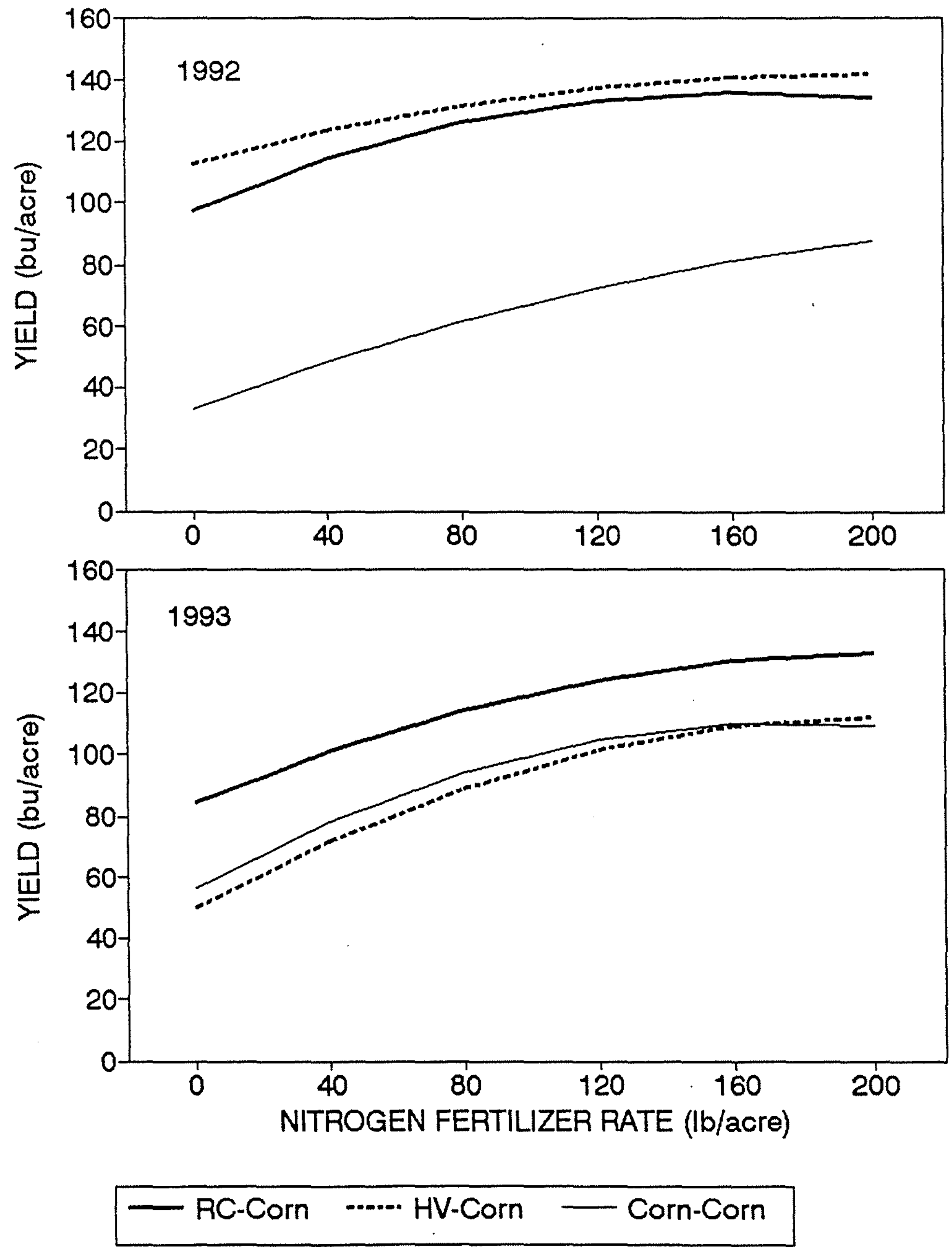

Figure 24. Quadratic regression curves for the response of rotated and non-rotated corn to nitrogen fertilizer.

D. Establishing Green Manure Crops After Small Grains

E. B. Mallory*

Introduction

In addition to enhancing soil fertility, structure and nutrient content, cover crops have long been recognized for their soil conservation benefits (Bruce et al., 1987; Langdale et al., 1991; Williams et al., 1981). Short season crops, such as small grains or processing crops, may leave the field vulnerable to soil erosion and weed invasion after mid- to late-summer harvest. At the same time, these crops create an ideal "window" to establish cover crops. Seeded in the late summer, cover crops protect the soil from erosion from early fall until seedbed preparation the next spring.

A major concern with this cover crop system, however, is that seedbed preparation, performed to insure good establishment of the cover crops, may actually negate their soil conservation benefits by burying the main crop residue and exposing the field to erosion during mid-summer when the potential for erosion is relatively high (Pingry, personal communication, Sloneker and Moldenhauer, 1977). Wischmeier and Smith (1978) estimate that 13%, 11% and 9% of yearly erosive rainfall occurs during the periods of July 1 - 14, July 15 - 31, and August 1 - 15, respectively. Additionally, the time and expense involved in seedbed preparation may exceed that which a farmer is willing to invest to establish a non-cash crop.

In our study, we compared five methods of establishing cover crops following small grains. The objective was to identify the method that maximizes cover crop establishment and growth, and minimizes soil disturbance.

Materials and Methods

Five methods of establishing cover crops after small grain harvest were compared in 1992 and 1993 at the University of Wisconsin Research Station near Arlington, Wisconsin. In 1992, one experiment was conducted with oats (Avena sativa L.) as the main crop. In 1993, the experiment was repeated on an adjacent field with oats, and on a neighboring field with winter wheat (Triticum aestivum L.). All three experimental fields were in field corn during the preceeding year. Corn was harvested for grain before the oat experiments and harvested for silage before the winter wheat experiment. The trials were done on a Plano silt loam (fine-silty, mixed, mesic Typic Arguiudoll), 2 to 4% slope.

Treatments were a 2 x 5 factorial combination of cover crop species and establishment method (Table 25). The control treatment was no cover crop, no disturbance. Red clover (RC) (Trifolium pratense L.) and hairy vetch (HV) (Vicia villosa Roth) were the selected cover crops because they represent a small and a large seeded species with presumably different seedbed preparation needs. Furthermore, RC and HV had been previously identified in a screening study in Wisconsin that evaluated several leguminous cover crops for high biomass production and nitrogen yield (Stute, 1991; Stute and Posner, 1993).

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Table 25. Treatments used to establish green manure crops after small grains.

Treatment code	Species	Seedbed preparation after oat harvest	Seeding method
RC-CS	Red clover	None	Companion-seeded
HV-CS	Hairy vetch		with small grains
RC-NT	Red clover	None	No-Till Drill
HV-NT	Hairy vetch		
RC-CD	Red clover	None	Conventional drill
HV-CD	Hairy vetch		with cultipacker
RC-D1	Red clover	Tandem disk (1 pass)	Conventional drill
HV-D1	Hairy vetch		
RC-D2	Red clover	Tandem disk (2 passes)	Conventional drill
HV-D2	Hairy vetch		
Control	None	None	None

Five establishment methods provided a realistic range of tillage for cover crop seedbed preparation and of resulting residue disturbance. Companion-seeding, the low end of this range, required no disturbance after small grain harvest. Cover crops were either frost seeded into winter wheat (April 2, 1993) or drilled with oats at planting (April 30, 1992 and 1993). All other establishment methods occurred immediately after small grain harvest (1992 oats, August 12; 1993 wheat, August 4; 1993 oats, August 12). Appropriate inoculant was applied to the cover crops before seeding.

The experimental design was a randomized complete block, replicated three times. Individual plots measured 10′ x 35′.

Oat and wheat yields (grain and straw) were measured to determine if they were affected by the companion-seeded cover crop treatments (RC-CS and HV-CS). Three randomly selected 5.4 ft^2 areas in each plot were hand harvested from the RC-CS, HV-CS, and control treatments and cover crop herbage was removed. The small grain samples were threshed and weighed. Grain was subsampled to determine moisture content, and yields were corrected to 13% moisture.

Ground cover was monitored in all plots using the line transect method (Laflen et al., 1981). In 1992, ground cover was measured immediately following sequential cover crop seeding (week 0), and at 2 week intervals until ground cover reached 80% or greater. In 1993, ground cover was measured at weeks 0, 2, 4 and 6, and a final ground cover measurement was taken following a killing frost. In both years, above-ground biomass yields were estimated by harvesting three random 5.4 ft^2 areas, one inch above the soil surface after the first killing frost. Samples were separated into cover crop, weed and volunteer crop fractions, dried at 140° F for 3 days and weighed.

Results and Discussion

Small Grain Yields

Companion-seeded cover crops did not affect small grain yields in any experiment (data not shown). This result is deceptive in light of our sampling method, which measured the production, but not the harvestability, of grain and straw. This distinction is important for hairy vetch, which has a climbing growth habit. While the vetch did not decrease grain or straw production, it climbed up the small grain stems and created a solid mat over the grain heads, thereby making the crop unharvestable by machine. For this reason, hairy vetch is unsuitable as a companion cover crop.

Red clover, on the other hand, affected neither grain yield nor harvestability. However, straw cut at normal height contained red clover herbage. If the combine were set higher to avoid the clover herbage, straw yields would be reduced. This may be a concern to farmers given the current wheat market where they can earn as much, or more, from clean straw ($90-100/ton for oat and wheat straw (Burger, personal communication)) as from grain ($74 and $92/ton for oat and wheat grain, respectively (WDATCP, 1993)).

Grain yields in this trial for the 1992 oat, 1993 oat and 1993 winter wheat crops were, in order, 1.5, 1.5 and 1.0 ton/acre. Respective straw yields were 1.7, 1.6, and 2.2 ton/acre.

Ground Cover

Both cover crops gave similar ground cover in all experiments. However, establishment method had a significant effect on ground cover development. Additionally, cover crop X establishment method interactions were significant late in the season in 1993 experiments (Table 26). These findings indicate that red clover and hairy vetch provided equal soil protection when data are averaged over all the establishment methods, but that, in 1993, the two species performed differently under different establishment methods (Figs. 25 and 26). In contrast to companion-seeded red clover, which was equal to the best treatments (other top RC treatments were NT and CD), companion-seeded hairy vetch recovered poorly after small grain harvest and provided less cover than vetch under NT and CD. However, these differences are not important considering that (a) more than sufficient ground cover was provided in all of the treatments discussed and (b) companion-seed hairy vetch is an unsuitable option anyway because it interferes with small grain harvest.

The establishment methods used gave us a narrower range of residue disturbance than expected (Figs. 25 and 26). For instance, based on general estimates (Anderson, 1968), one pass of a tandem disk should reduce residue to 50% of the original residue cover, but we observed ground cover was reduced to only 66 to 83% of the undisturbed control treatment (Table 27). These values are at and above the high end of the range estimated by the Soil Conservation Service, possibly due to the use of lighter, plot-sized equipment, versus heavier, field scale implements, and slower operating speeds (SCS, USDA and Equipment Manufacturers Institute, 1992).

In 1993, the minimal disturbance treatments (C, NT and CD) provided greater than 87% cover from small grain harvest into the fall in both experiments (Figs. 25 and 26). Tandem disking reduced ground cover significantly as compared to the minimal disturbance methods. Whereas, with wheat, two diskings reduced cover even further, the second disking had no significant effect in the oat experiment.

Table 26. Analysis of variance for percent ground cover at 0, 2, 4 and 6 weeks following sequential seeding and after the first killing frost in the fall.

Experiment / Source of variation	df	Weeks after sequential seeding: 0	2	4	6	frost
1992 Oats						
Replicates	2	NS	NS	NS	-	-
Treatments	10	**	**	†	-	-
Control vs. factorial	1	**	NS	NS	-	-
Factorial	9	**	**	**	-	-
Cover crop (CC)	1	NS	NS	NS	-	-
Establishment (Est)	4	**	**	**	-	-
CC x Est	4	NS	NS	NS	-	-
CV (%)		8.6	7.7	4.7	-	-
1993 Oats						
Replicates	2	NS	NS	NS	NS	NS
Treatments	10	**	**	**	**	**
Control vs. factorial	1	†	*	*	*	NS
Factorial	9	*	**	**	**	**
Cover crop	1	NS	NS	NS	NS	NS
Establishment	4	**	**	**	**	NS
CC x Est	4	NS	NS	**	**	**
CV (%)		18.0	14.6	4.7	2.2	1.7
1993 Wheat						
Replicates	2	NS	NS	NS	NS	NS
Treatments	10	**	**	**	**	NS
Control vs. factorial	1	**	**	NS	NS	**
Factorial	9	**	**	**	**	NS
Cover crop	1	*	NS	NS	NS	NS
Establishment	4	**	**	**	**	NS
CC x Est	4	NS	NS	*	**	NS
CV (%)		5.6	4.3	2.2	0.7	0.2

†, *, ** Significant at 0.10, 0.5 and 0.01 probability levels.
NS not significant (P > 0.10).

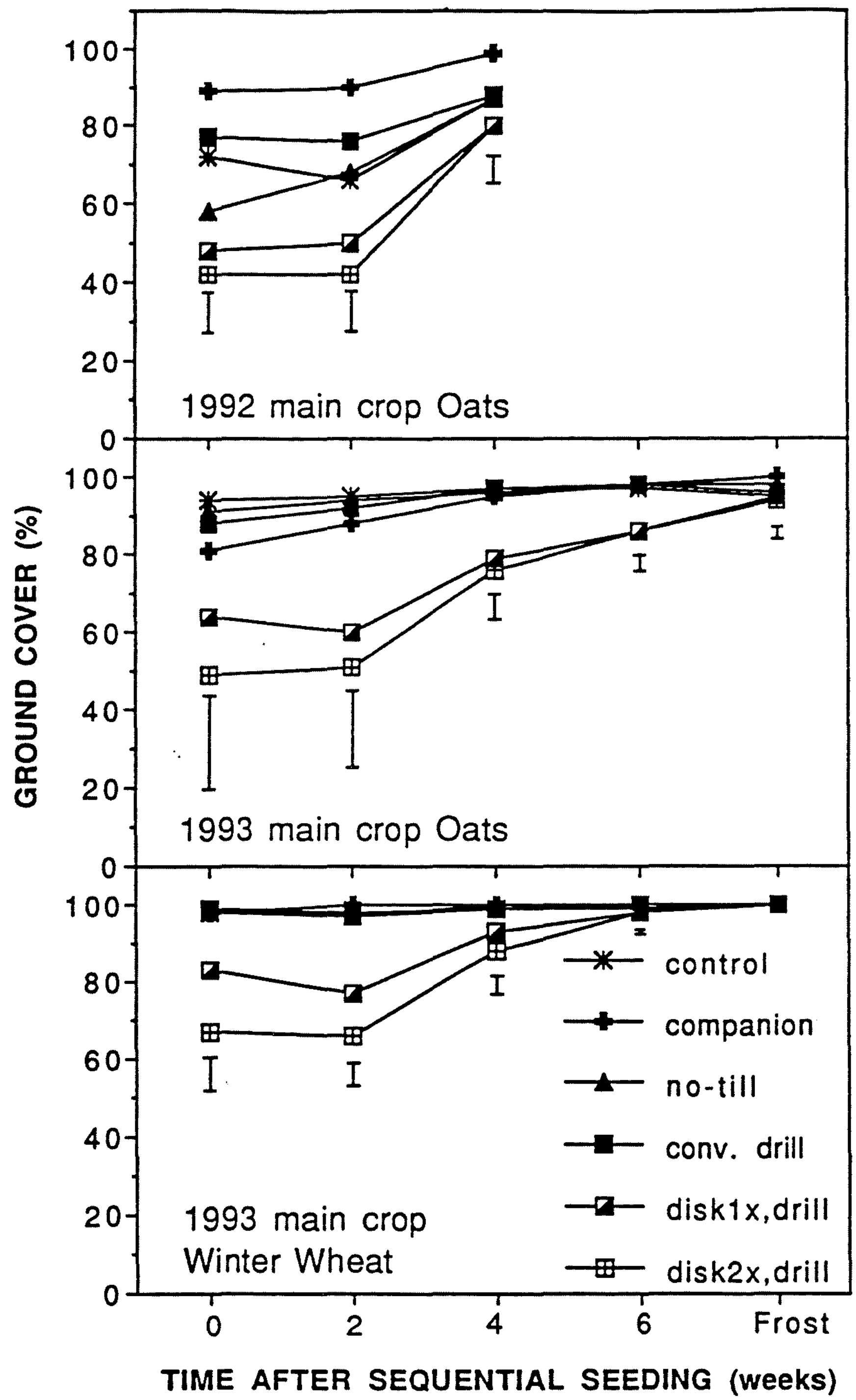

Figure 25. Effect of red clover establishment method on ground cover development over the period from sequential cover crop seeding to first killing frost for three experiments. Vertical bars indicate LSD (P = 0.05) and apply within sampling date.

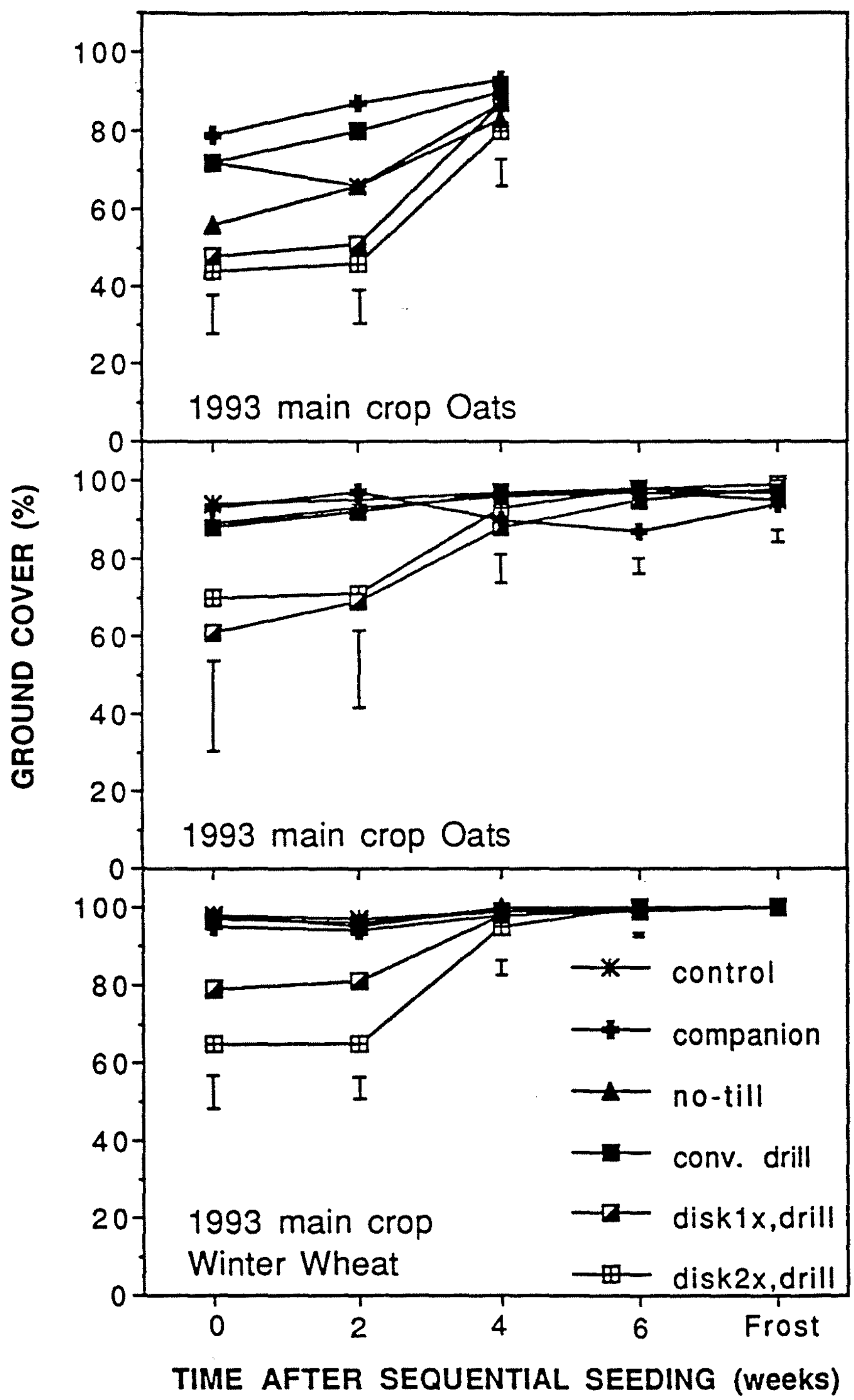

Figure 26. Effect of hairy vetch establishment method on ground cover development over the period from sequential cover crop seeding to first killing frost for three experiments. Vertical bars indicate LSD (P = 0.05) and apply within sampling date.

Table 27. Percent residue remaining after different methods of establishing cover crops following small grains as compared to Soil Conservation Service estimates.

Establishment method	Experiment 1992 oats	1993 oats	1993 wheat	SCS estimate†
	---------- Residue remaining (%) ----------			
Companion seeded#	100‡	100	§	
No-till drill	100	100	100	85-95
Conventional drill	79	100	100	80-100
Tandem disk 1x	67	66	83	40-70
Tandem disk 2x	60	63	67	§

† Source: SCS, USDA, and Equipment Manufacturers Institute, 1992.
‡ 100% indicates that difference between treatment and control was not significant.
§ Not estimated.
# Companion seeding resulted in greater cover versus control treatment.

Minimal disturbance treatments resulted in a wider range of ground cover in 1993 than in 1992 (Figs. 25 and 26). Comparisons of ground cover at week 0 in the control treatments suggest that there was less residue to begin with in 1992. This may have accentuated the differences between the minimal disturbance treatments in 1992, as compared to 1993 where initial residues were higher. As compared to the control, ground cover was increased by the companion treatment, unaffected by the no-till treatment and decreased by the conventional drill treatment. Residue levels after one and two diskings were statistically similar and were the lowest of all the treatments.

In spite of treatment differences, residue levels never dropped below 40% in any experiment, and all treatments provided greater than 80% ground cover by four weeks after seeding.

Biomass production

Both cover crops produced similar biomass yields, yet establishment method and the cover crop X establishment method interaction was significant in most cases (Table 28). Therefore, biomass yields, as composed of cover crop, weed and volunteer crop fractions, are presented for each combination of cover crop and establishment method (Fig. 27).

Companion-seeding was consistently the best establishment method for red clover in terms of biomass production. This treatment produced the most cover crop and total biomass, and provided 100% weed control (Fig. 3). Sequential treatments failed to establish red clover in 1992. In 1993, red clover yields were low and statistically equivalent across treatments following oats. Following wheat, the one disking and NT treatments resulted in the best establishment. Total biomass in the red clover treatments was equivalent across sequential treatments in each experiment.

Table 28. Analysis of variance for cover crop, weed, volunteer crop and total above-ground dry matter yields.

Source	df	Cover crop	Dry matter fraction Weeds	Volunteer crop	Total
1992 Oats					
Replicates	2	NS	NS	**	**
Treatments	10	**	*	**	**
Control vs. factorial	1	**	**	NS	*
Factorial	9	**	NS	**	**
Cover crop (CC)	1	NS	NS	NS	NS
Tillage	4	**	NS	**	**
CC x Tillage	4	**	NS	*	†
CV (%)		39.3	148.7	19.7	17.6
1993 Oats					
Replicates	2	NS	NS	NS	NS
Treatments	10	**	**	*	**
Control vs. factorial	1	*	**	NS	†
Factorial	9	**	**	*	**
Cover crop (CC)	1	NS	NS	NS	NS
Tillage	4	**	**	**	**
CC x Tillage	4	**	*	NS	**
CV (%)		71.1	47.5	88.0	33.0
1993 Wheat					
Replicates	2	NS	NS	NS	†
Treatments	10	**	**	**	**
Control vs. factorial	1	**	**	NS	**
Factorial	9	**	**	**	**
Cover crop (CC)	1	NS	NS	NS	NS
Tillage	4	**	**	*	*
CC x Tillage	4	**	*	**	**
CV (%)		28.6	53.1	99.2	12.0

†, *, ** Significant at 0.10, 0.5 and 0.01 probability levels.
NS Not significant ($P > 0.10$).

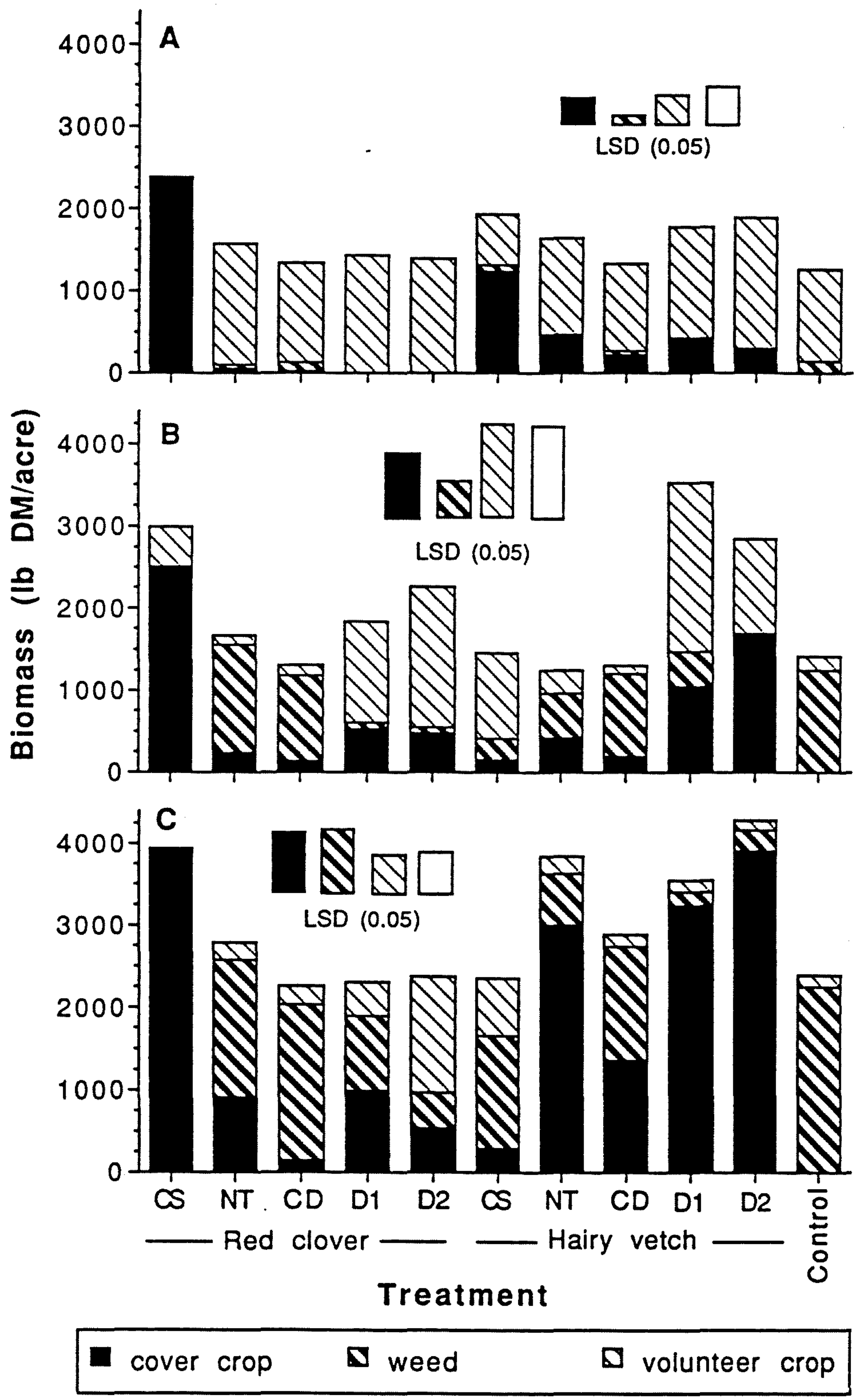

Figure 27. Effect of cover crop species and establishment method on dry matter biomass yields for experiments (A) 1992 oats, (B) 1993 oats and (C) 1993 winter wheat. Bar heights are total biomass yields, divided into cover crop, volunteer crop and weed fractions. Total biomass LSD is indicated by the unfilled LSD bar.

Because hairy vetch is unsuitable as a companion cover, we were primarily interested in its performance when sequentially seeded. While total biomass production varied greatly between experiments, vetch biomass production followed the pattern we expected to see in terms of residue disturbance: two diskings > one disking > no disking > no-till drill. Differences between sequential treatments were not all statistically significant in 1993, and none were in 1992.

In general, both vetch and clover biomass yields were greater following winter wheat than oats. Winter wheat is harvested earlier than oats, allowing for earlier sequential seeding. In our experiments, wheat harvest occurred one week earlier than oat harvest. However, given our limited data, we can not draw any conclusions regarding seeding date and biomass yield.

Biomass data also show the effect of the different establishment methods on weed and volunteer small grain growth. In terms of weed suppression, the control treatment provides the background weed biomass values against which the different treatments can be compared. Companion-seeded red clover provided the most weed control (100%). High levels of control were obtained with the disking treatments; as would be expected, the disturbance associated with seedbed preparation helped control weeds. In some cases disking also helped establish volunteer small grains.

Conclusions

In terms of soil protection and biomass production, companion-seeding is the best method to establish red clover. However, concerns about straw yield losses may motivate some farmers to look for an alternative. Because red clover yields are low when seeded after small grain harvest, hairy vetch would be the best choice for sequential seeding. When choosing a method for establishing hairy vetch, a small trade-off may occur between maintaining surface residues and maximizing vetch biomass production. If soil protection is the primary concern, the no-till drill resulted in better establishment and growth of vetch than did using a conventional drill with no seedbed preparation. However, not all farmers have access to a no-till drill. In that case, only light tillage, which leaves 40% or more ground cover, is necessary to assure good establishment.

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E. Performance and Profitability of Cover Crops in Cash Grain Rotations: On-farm Trials

Ellen Mallory and Josh Posner*

Introduction

Cover crops have gained attention in recent years for their ability to control soil erosion and reduce farmers' dependence on commercial fertilizers (Karlen and Sharpley, 1994; Reeves, 1994). Erosion can substantially reduce soil productivity as well as pollute surface waters with sediment, nutrients and chemicals transported in runoff (Bruce et al., 1987; WDATCP, 1990). Despite long-standing federal and state soil conservation programs, soil erosion continues to be a major concern. In Wisconsin, erosion rates exceed the tolerable soil loss rate, or "T", on 35% of the total cropland (WDATCP, 1990). Cover crops both maintain and rebuild soil resources by reducing runoff and erosion (Karlen and Sharpley, 1994) and by adding organic material to surface soils (Bruce et al., 1987).

Research focusing on the nitrogen (N) fixing benefits of leguminous cover crops has been prompted by concerns that commercial N fertilizers are expensive (Heichel and Barnes, 1984), energy intensive and potential environmental hazards (Magdoff, 1991). Numerous studies have demonstrated that a leguminous winter cover crop, such as hairy vetch (<u>Vicia</u> <u>villosa</u> Roth), can provide some, if not all, of the N needed by a non-leguminous crop (Ebelhar et al., 1984; Hargrove, 1986; Mitchel and Teel, 1977; Smith et al., 1987; Voss and Shrader, 1984). Particular attention has been paid to corn (<u>Zea</u> <u>mays</u> L.) production because it is the major food, feed and forage crop in the U.S. and has high N needs (Heichel, 1987; Stute and Posner, 1993).

Most cover crop research, and agricultural research in general, is conducted on experiment stations with inadequate input from its intended users, farmers (Rzewnicki, 1991). On-station research attempts to make generalizations from results gathered in small, highly-controlled environments. One consequence is that decades can pass before station-developed technologies are adapted to individual situations and adopted by the general farm community (Rzewnicki, 1991). On-farm research, conducted with farmers as collaborators and managers, can speed up technology transfer by assuring the relevance of the technology, increasing its visibility and testing its adaptability over a range of farm conditions (Anderson, 1992; Byerlee et al., 1982; Edwards, 1993; Rzewnicki, 1991).

We took an on-farm approach in Wisconsin to study the benefits of incorporating cover crops into cash grain rotations. An optimal time to include cover crops is following sole-seeded small grains or processing crops. Typically, the half million acres (WDATCP, 1993) on which these short season crops are grown annually in Wisconsin are either tilled or left fallow after harvest (July to early August) and then planted to corn the following spring. Leguminous cover crops could protect soil from erosion after short-season crop harvest and contribute N to the following corn crop. An on-station study screened a variety of forage legumes and two seeding times within the context of a two-year oat/corn rotation. Two cover crop options were identified as the most promising species in terms of dry matter and N production: companion-seeded red clover (<u>Trifolium</u> <u>pratense</u> L.) and sequentially-seeded hairy vetch each yielded up to 150 lb N/acre (Stute, 1991).

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In collaboration with six farmers and one Future Farmers of America group, we evaluated this cover crop system over a variety of soil types, short-season crops and farmer management techniques. Four cover crops were compared for their ability to provide soil protection after short-season crop harvest, and to contribute N to a subsequent corn crop.

Materials and Methods

The cover crop study started in 1992 on five private farms and one high school demonstration field in south-central Wisconsin. Sites were selected based on farmer interest and on soil type: three sandy loams and three silt loams, ranging from 1 to 4.1% organic matter and 0 to 12% slope.

The experimental design at all sites was a randomized complete block with three replications, and a split plot arrangement of N fertilizer rates in the fallow check plots during the corn year (Fig. 28). Plot widths were multiples of the farmers' equipment, with individual plot sizes ranging from 0.04 to 0.12 acres. The short-season crop/cover crop (phase I) plots were established at each farm in 1992, and again on nearby fields in 1993. Corn (phase II) was planted into the 1992 and 1993 phase I plots in 1993 and 1994, respectively.

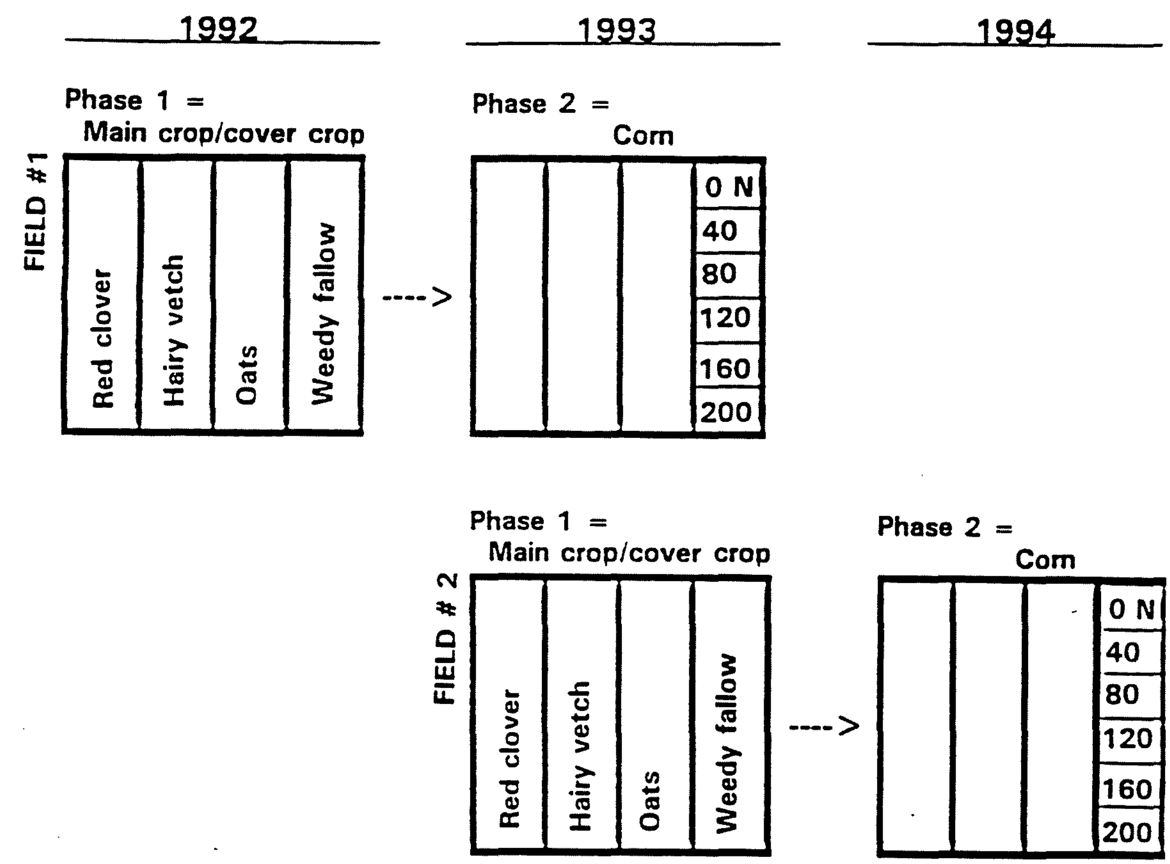

Figure 28. Schematic diagram of the three-year demonstration trial located on five farms and one high school. Only one of three replicates is shown.

Phase I (Short-season Crop/ Cover Crop)

Farmers grew one of four short-season crops (winter wheat (Triticum aestivum L.), oats (Avena sativa L.), peas (Pisum sativum L.) or snapbeans (Phaseolus vulgaris L.)) with at least three of the cover crop treatments listed in Table 29. Most farmers used companion-seeded red clover, sequentially seeded hairy vetch and sequentially seeded oats. There were two exceptions. Klahn and Manke established red clover following snapbean harvest (sequentially seeded) instead of companion seeding. Baldock planted all four cover crop treatments. All farmers applied the appropriate inoculant before seeding and all included a weedy fallow check plot as a treatment.

"Companion-seeded" red clover was either frost-seeded into winter wheat, drilled with oats at oat seeding, or broadcast-seeded immediately following pea seeding. Although all of these seeding methods are not technically companion seeding, they will be referred to as such in this report. In contrast, "sequential seeding" refers to establishing the cover crops after short-season crop harvest. Each farmer decided how to establish the sequentially seeded cover crops. Seedbed preparation ranged from intensive to none.

Ground cover was measured in all plots with the line transect method (Laflen et al., 1981) immediately following sequential cover crop seeding (week 0) and at 2, 4 and 6 weeks thereafter. A final ground cover measurement was taken following a killing frost (26° F for 6 hours). At that time, the above-ground dry matter (DM) yield of each treatment was estimated by harvesting three random 5.4 ft^2 areas, one inch above the soil surface. Samples were separated into cover crop and weed fractions, dried at 140° F for 3 days and weighed. To measure N content in the DM, these fractions were ground to pass through a 1 mm screen and analyzed for percent N using a Leco N determinator (Leco Corp., St Joseph, MI, 49085).

Table 29. Cover crop species, establishment method and seeding rate.

Species	Cultivar	Establishment method	Seeding rate (lb/acre)
Medium red clover			
(*Trifolium pratense* L.)	Arlington	companion	12
		sequential	12
Hairy vetch			
(*Vicia villosa* Roth)	common	sequential	30
Oat			
(*Avena sativa* L.)	Horicon	sequential	64

Phase II (Corn)

Farmers killed the cover crops in early spring, with tillage or herbicides, and then grew corn by their usual practices (with the exclusion of N fertilizer). Corn following the weedy fallow check plot was hand fertilized at six N rates (0 - 200 lb/ac) at planting.

Corn grain yields were determined by hand harvesting 20 feet of the two center rows of each plot. Ears were shelled and grain subsamples were taken to determine moisture and percent N. Yields were corrected to 15.5% moisture.

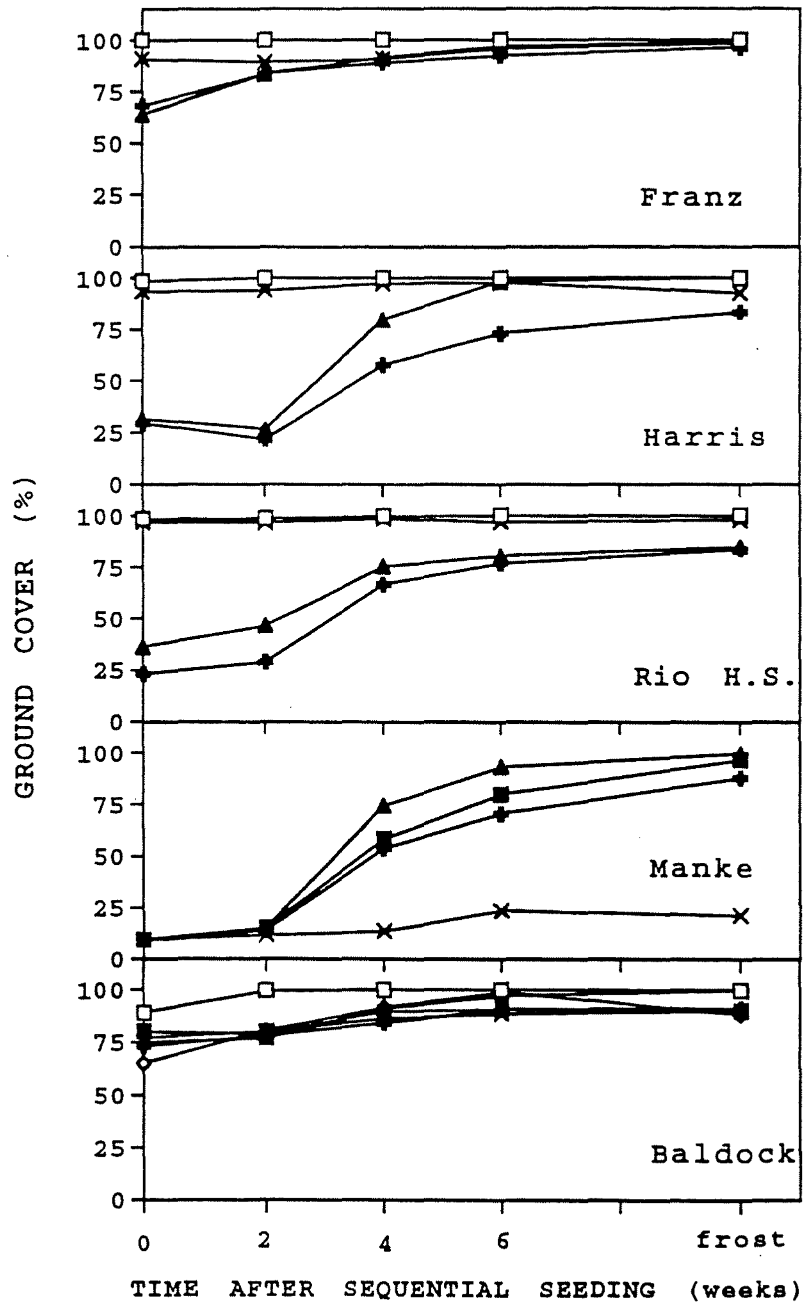

Figure 30. The effect of cover crop treatment on 1993 ground cover from sequential cover crop seeding in mid-summer until the last killing frost in the fall. Cover crop treatments are: companion-seeded red clover (□), sequentially seeded red clover (■), hairy vetch (▲), oats (+), buckwheat (◆), and fallow control (x).

Above-Ground Biomass Yields

Total above-ground biomass, or dry matter (DM), yields are represented in Figs. 31 and 32. Biomass samples were separated into cover crop, weed, and volunteer crop partitions, and each was measured separately. The stacked bars in the graphs reflect this partitioning.

Cover crop biomass yields varied greatly among treatments at any one site, and among sites for any one treatment. In general, total DM yields were lower at the Rio, Franz and Benck sites. At first glance, the fact that these are all sandy sites, and the others are silt loams, seems to explain this difference. However, sequential cover crop planting dates also tended to be later at the sandy sites. Therefore, soil type and sequential planting date are confounded and cannot be separated as effects.

Are soil type and sequential planting date confounded by coincidence or by correlation? Given the handful of sites, coincidence, as the null hypothesis, cannot be ruled out. Coincidence seems even more likely when we consider that sequential planting date was affected by main crop harvest dates and that the farmers grew a variety of main crops. (Two of the three main crops grown on the silt loams were early contract processing crops. In general, they are harvested before small grains, allowing for earlier seeding of the sequential cover crops.)

In contrast to the general variability observed, companion-seeded red clover consistently ranked highest, or equivalent to highest, for total DM production at each farm-year. One exception occurred at the Baldock farm in 1992. Here, the contractor mechanically harvested the peas under wet conditions, leaving deep tire tracks and damaging much of the established red clover stand. Overall, however, companion-seeded red clover appeared to benefit from the head start it gets over the later-planted cover crops.

Sequentially seeded treatments were planted relatively late in both 1992 and 1993 at many of the farms due to delayed small grain harvests, a statewide phenomena. Winter wheat and oat harvests are usually 86 and 78% complete in Wisconsin by August 15, based on a 5-year average (WDATCP, 1992). However, harvests were only 56 and 24% complete in 1992, and 50 and 26% complete in 1993, for winter wheat and oats, respectively. A one or two week difference in seeding date can significantly affect dry matter accumulation of sequentially planted cover crops (Stute and Posner, 1993). This was especially true in the 1992 and 1993 seasons because August rainfall was below average both years. Additionally, growing degree days in July and August of 1992 were much fewer than usual.

Cover crop N contributions

Using the N content of above-ground biomass as a measure of N production of cover crops has two major limitations. First, the root to shoot ratio of total N differs among cover crop species. Thus, relative above-ground biomass N values may not accurately reflect relative total biomass N content. Second, our method of measuring the N content of the above-ground biomass does not distinguish between N that was derived from the soil from N that was fixed by the legume cover crop. In spite of these limitations, above-ground biomass N is useful as a rough estimate of relative N contributions of the cover crops.

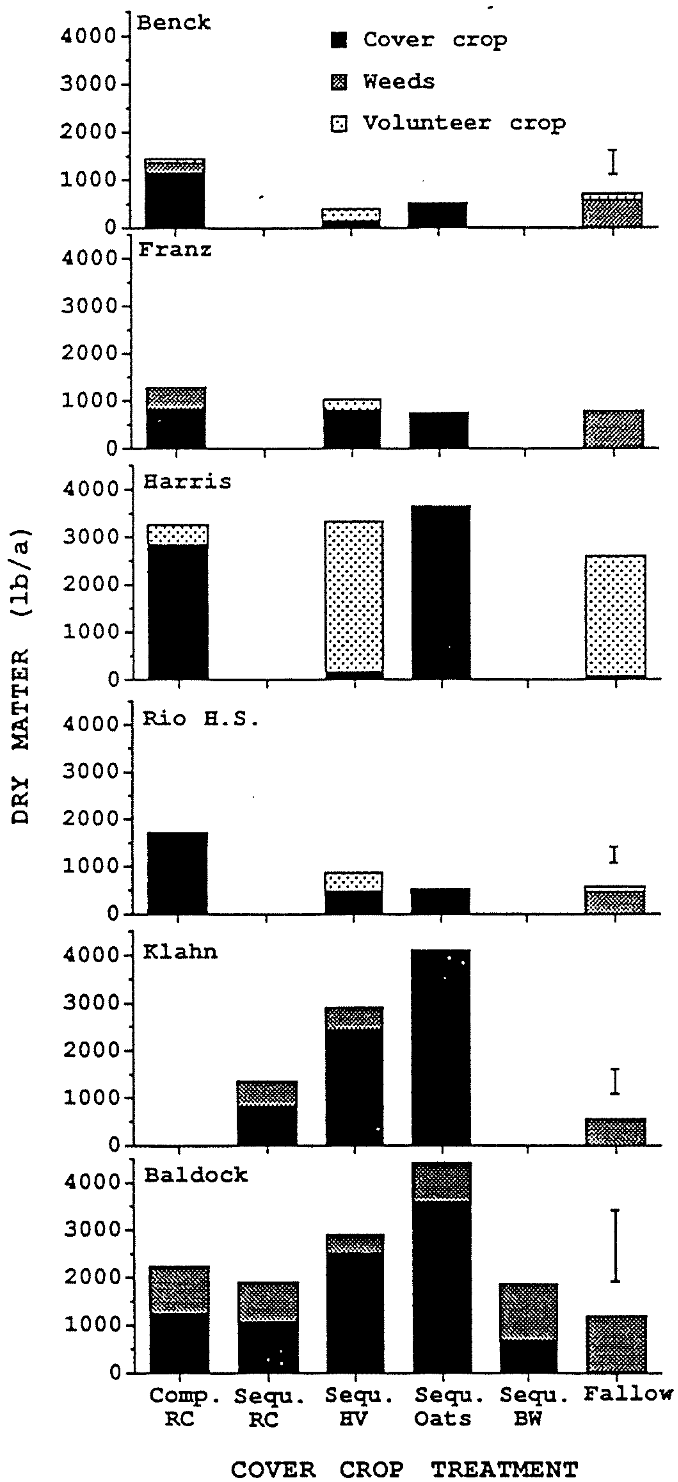

Figure 31. The effect of cover crop treatment on 1992 above-ground dry matter yields. Vertical bars indicate the LSD (0.05) between total DM yields where significant differences occurred.

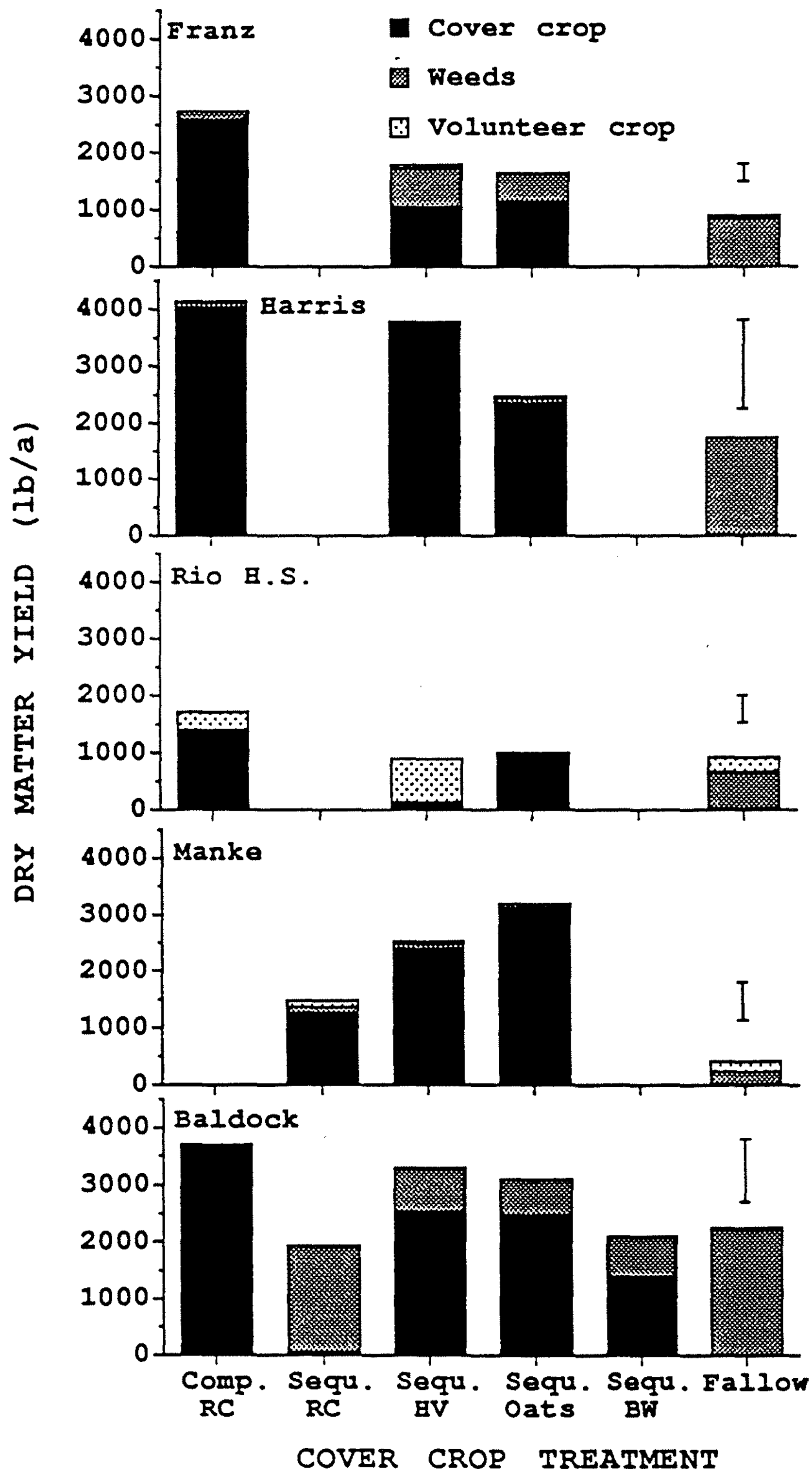

Figure 32. The effect of cover crop treatment on 1993 above-ground dry matter yields. Vertical bars indicate the LSD (0.05) between total DM yields where significant differences occurred.

Cover crop treatment significantly affected N content at all farm-years, with N content values ranging from 7.4 to 162.8 lbs N/acre (Table 30). Leguminous cover crop treatments had the highest N yield at each farm-year. Companion-seeded clover (26.5 to 118.1 lb N/acre) yielded more than sequentially seeded clover (1.9 to 48.8 lb N/acre). Hairy vetch was the most variable of the cover crops (4.9 to 162 lb N/acre), yet yielded more than 100 lb N/acre at five of the eleven farm-years. Oat N content ranged from 7.4 to 84.7 lb N/acre. It was higher following leguminous main crops (peas and snapbeans) than small grains, which is consistent with observations that the N content of grass cover crops depends largely on soil N availability (Reeves, 1994).

Table 30. Nitrogen accumulation in cover crop above-ground biomass in 1992 and 1993.

	Farm					
	Franz	Harris	RIO H.S.	Klahn/ Manke	Baldock	Benck
	1992 - N accumulation (lb/ac)					
Companion red clover	26.5	86.9	49.3	-	44.1	38.5
Sequential red clover	-	-	-	29.6	39.5	-
Sequential hairy vetch	26.8	7.0	16.3	103.2	111.0	4.9
Sequential oats	14.5	54.4	7.4	84.7	67.7	12.9
Weedy fallow†	17.9	38.6	8.2	12.3	28.8	14.3
LSD (0.05)	NS	36.6	14.0	40.8	46.9	12.9
	1993 - N accumulation (lb/ac)					
Companion red clover	76.0	101.8	42.9	-	118.1	-
Sequential red clover	-	-	-	48.8	1.9	-
Sequential hairy vetch	45.1	162.8	6.1	107.2	110.2	-
Sequential oats	15.7	38.2	19.5	69.4	45.7	-
Weedy fallow†	18.2	20.1	15.3	15.4	49.7	-
LSD (0.05)	14.1	71.6	8.9	23.5	17.5	-

† Includes weeds and volunteer crop.

Corn grain yields

In general, the cover crop effect was insignificant; grain yields following cover crops were equivalent to those following weedy fallow (Table 31). It is suspected that N was either lost, through leaching or denitrification, or slow to mineralize during the excessively wet 1993 season. In general, though, corn following leguminous cover crops (red clover and hairy vetch) tended to yield more than that following the non-leguminous cover crop (oats). This is consistent with previous observations (Blevins et al., 1990; Bollero and Bullock, 1994; Reeves, 1994).

Corn following red clover and hairy vetch yielded similarly, except at the Franz farm where corn yields following the vetch exceeded corn fertilized at 200 lb N. Observations taken during the corn season suggest that this result may be due as much to weed control as to N benefits provided by the vetch. Teasdale et al. (1991) noted the weed suppression benefits of hairy vetch in no-till systems. Franz killed his cover crops with herbicides and no-till planted his corn. Due to excessive moisture, he was unable to cultivate or spray for weed control. Consequently, weed pressure was extremely high in all but his vetch plot, where a thick mat of vetch prevented weeds from germinating.

Corn grain yields following weedy fallow were significantly affected by N fertilizer rate at three of the five farms (Table 3). At the other two farms (Klahn and Baldock) leguminous main crops, snapbeans and peas, preceded the corn and may have muted its response to added N. In general, corn yields following the cover crop treatments were equivalent to those following weedy fallow, fertilized at 0 to 120 lb N/acre.

Table 31. Grain yields of corn that followed either cover crops (no additional N) or weedy fallow (0 to 200 lb N/ac applied to corn).

	Farm				
Treatment	Franz	Harris	Rio H.S.	Klahn	Baldock
	(bu/ac)				
Companion RC	43	125	105	-	129
Sequential RC	-	-	-	141	109
Sequential HV	83	127	94	144	132
Sequential oats	34	112	60	124	108
Weedy fallow (0 N)	13	120	71	126	106
LSD (0.05)	29	NS	NS	NS	NS
Contrasts					
Cover crop vs. fallow	**	NS	NS	NS	NS
Legume vs. non-leg.	*	†	*	NS	†
RC vs. HV	*	NS	NS	NS	NS
Weedy fallow					
0 N	13	120	71	126	106
40 N	19	135	80	149	130
80 N	40	139	111	152	128
120 N	70	143	125	157	128
160 N	79	147	142	152	144
200 N	79	145	132	169	129
LSD (0.05)	22	8	15	NS	NS

†, *, ** significant at the 0.10, 0.05 and 0.01 probability levels, respectively, as determined by an F test.

Conclusions

The objectives of this study were: 1) to test the on-farm adaptability of a cover crop system that had been developed on-station, and 2) to compare different cover crop options, in this system, for their ability to provide ground cover and supply nitrogen to a following corn crop. The variety of sequential seeding and cover crop kill methods used by the farmers demonstrates that this system can be easily adapted to individual farm situations. However, performance of the cover crops varied greatly among farms and years. It is not known how much of this variability should be attributed to differences in: management styles, soil types, sequential seeding timing, weather, or other factors. The number of farms was too few to separate these effects. It can be said, however, that some of the risk associated with this variability may be reduced with timely sequential seeding (i.e. mid- to late-July). For this reason, short-season crops which are harvested relatively early, such as winter wheat and early contract processing crops, are more suited to this cover crop system than those which are harvested later, such as oats.

Ground cover depends more on the establishment method than on the cover crops themselves. Companion-seeded red clover provided the greatest soil protection, virtually 100% immediately following short-season crop harvest and into the fall. The companion clover also provided high levels of weed control. However, this option may not be chosen by farmers who need to sell clean small grain straw. Sequentially seeded cover crops do not interfere with the short-season crop but mid-season seedbed preparation can increase the potential for erosion during a period of two to four weeks after seeding. If soil protection is a primary concern, no-till sequential seeding is a solution. However, this option does not provide as much weed control.

Both legume cover crops demonstrated the potential to produce significant amounts of N by the fall after seeding. It is suspected, however, that some cover crop N, as well as fertilizer N, was either lost, through leaching or denitrification, or slow to mineralize during the excessively wet 1993 season. While red clover and hairy vetch had positive effects on corn grain yields, their effects were lower than expected.

The on-farm cover crop trial will be completed after the 1994 corn data is collected. Given that the first corn year was excessively wet, the data from 1994 season are critical in assessing the true on-farm potential of cover crops.

Economic Analysis

In order to evaluate the profitability using cover crops as a sole source of nitrogen for corn production, a partial budget analysis was conducted by calculating the gross margins for each treatment. Although the analysis was limited to the corn year of the rotations, production costs for the cover crop treatments included the cost of cover crop seed and seeding incurred the previous year, as well as interest on those outlays.

Gross margins for both cover crop and fertilizer treatments were positive in most cases (Table 32). Negative gross margins occurred at the Franz farm where excessively wet weather prevented weed control, likely caused N loss, and resulted in low corn yields. The only other case where a gross margin was negative was the oat treatment at Rio where N leaching was observed and yields were also relatively low.

As a sole source of N, cover crops were never the most profitable option. Rather, the weedy fallow treatment with 160, or 200, lb N/acre of fertilizer produced the greatest gross margin of all of the treatments at each farm. The average difference in gross margin between the best cover crop treatment and the best fertilizer treatment was $35.89/acre. However, cover crop treatments are disadvantaged by two shortcomings of this experiment and economic analysis: a) the cover crops options were not necessarily tested under economically optimal conditions, and b) the analysis does not account for long-term benefits of cover crops such as erosion control and improved soil physical conditions.

Table 32. Gross margins in 1993 of corn that followed either cover crops (no additional N) or weedy fallow (0 to 200 lb N/ac).

		Farm				
Treatment		Franz	Harris	Rio H.S.	Klahn	Baldock
		($/a)				
Companion RC	- Corn	-21.36	114.25	68.30	-	126.58
Sequential RC	- Corn	-	-	-	130.04	86.57
Sequential HV	- Corn	25.30	90.00	22.43	116.25	109.47
Sequential Oats	- Corn	-22.82	90.71	-7.72	122.56	98.74
Weedy fallow	- Corn					
fertilized with:	0 N	-47.53	119.89	23.24	133.89	102.41
	40 N	-45.43	140.82	32.87	167.23	139.41
	80 N	-15.17	142.80	85.44	167.69	110.99
	120 N	28.48	145.12	110.15	171.75	125.77
	160 N	39.94	147.02	132.86	158.96	149.77
	200 N	34.25	138.02	109.13	183.79	117.73

Testing under economically optimal conditions

In order to correctly evaluate the profitability of cover crop systems, these systems should be tested using their economically optimal production practices, e.g. optimal N fertilizer rates, seeding rates, establishment and kill methods, etc. (Allison and Ott, 1987). For instance, the profitability of cover crop systems increases when N fertilizer is used, such that the gross margin of corn following a cover crop is greater than that of corn with no cover crop when both corn crops are optimally fertilized (Frye et al., 1985; Hanson et al., 1993). While the addition of N fertilizer may have the greatest affect on gross margins, the profitability of cover cropping systems can also be increased by reducing input costs. Unfortunately, relatively little research has been done to determine optimal seeding rates (Allison and Ott, 1987) and establishment and kill methods.

Accounting for long-term effects of cover crops

Standard economic analyses, such as the present one, also underestimate the value of cover crops by failing to account for their positive, long-term effects (Allison and Ott, 1987; Shurley, 1987; Smith et al., 1987). These analyses usually measure the effects of a cover crop on the next year's crop only, whereas N or rotation effects may persist for many seasons (Hesterman et al., 1992) and accumulate (Frye et al., 1985). Likewise, soil protection and improvement benefits, while recognized by most researchers, are difficult to account for in standard economic analyses.

Although it is difficult to place monetary value on these long-term benefits, farmers are aware of them to some extent. The farmers participating in the on-farm trial said they would pay for erosion control (regardless of need to meet compliance), and, some, would pay for soil improving effects of cover crops. These farmers recognize that the long-term benefits of cover crops have value in terms of maintaining the future profitability of their systems.

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VI. Winter Wheat Establishment Following Soybeans

J. Hall*, J.L. Posner**, T.A. Mulder**

In the WICST Corn-Soybean-Wheat-Red Clover rotation (R3), the winter wheat is fall established during the same growing season the soybeans are in production. The winter wheat can be planted either before or after soybean harvest. If planted before soybean harvest, wheat seed must be broadcast on the soil surface. Since ground driven broadcast equipment will damage the soybean plants, most farmers apply seed by airplane if using this seeding method.

At the Lakeland Agriculture Complex, a WICST satellite experiment was designed to determine the best method for winter wheat establishment following soybeans. Two varieties and four methods of wheat seeding were tested. The varieties chosen were Merrimac (lower yield potential but very winter hardy) and Cardinal (higher yield potential but less winter hardy). Seeding times/methods were 1)broadcast at soybean leaf yellowing, 2)broadcast at soybean leaf drop, 3)broadcast after soybean harvest, and 4)no-till drilled after soybean harvest. A four repetition, split-plot design was used with main plots (wheat varieties) 20 ft (8 30" soybean rows) by 210 ft. Subplots (times/methods) were 10 ft by 210 feet for the drilled and 10 ft by 70 ft for the broadcast wheat (Fig. 33). Broadcasting was by hand, scattering wheat seed at the rate of 3 bu/a. Drilling was with no-till drill at 3 bu/a.

Wheat planting dates are summarized in Table 33. No measurements were taken in 1992 due to severe winterkill of all treatments. Wheat agronomists estimate that 80% of the winter wheat stands in southern Wisconsin were lost that year (pers. comm. E. Oplinger). Harvest of the 1992 plantings took place on July 19, 1993 with a small plot harvestor.

Winter kill and a cold wet spring reduced winter wheat yields. For both wheat varieties, wheat yield decreased as broadcast seeding was delayed and drilled wheat produced better than that broadcast after harvest (Fig 34). Over all times/methods, Cardinal yielded higher than the Merrimac variety. Combining varieties, yield was reduced significantly from 34 to 30 bu/A by delaying planting from soybean leaf yellowing to leaf drop and to 12 bu/A by waiting until after harvest. Drilled wheat yielded 29 bu/A which was not significantly different from broadcasting at leaf drop.

Winter survival of the wheat planted in the fall of 1993 was good and harvest results from these plantings are anticipated.

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<table>
<tr><td rowspan="4">Rep 1</td><td>Merrimac bdcst at leaf yellowing</td><td>Merrimac bdcst at leaf drop</td><td>Merrimac bdcst after harvest</td></tr>
<tr><td colspan="3">Merrimac no-till drilled after harvest</td></tr>
<tr><td colspan="3">Caldwell no-till drilled after harvest</td></tr>
<tr><td>Caldwell bdcst at leaf yellowing</td><td>Caldwell bdcst at leaf drop</td><td>Caldwell bdcst after harvest</td></tr>
<tr><td rowspan="4">Rep 2</td><td>Merrimac bdcst at leaf drop</td><td>Merrimac bdcst after harvest</td><td>Merrimac bdcst at leaf yellowing</td></tr>
<tr><td colspan="3">Merrimac no-till drilled after harvest</td></tr>
<tr><td>Caldwell bdcst after harvest</td><td>Caldwell bdcst at leaf drop</td><td>Caldwell bdcst at leaf yellowing</td></tr>
<tr><td colspan="3">Caldwell no-till drilled after harvest</td></tr>
<tr><td rowspan="4">Rep 3</td><td colspan="3">Caldwell no-till drilled after harvest</td></tr>
<tr><td>Caldwell bdcst at leaf drop</td><td>Caldwell bdcst at leaf yellowing</td><td>Caldwell bdcst after harvest</td></tr>
<tr><td colspan="3">Merrimac no-till drilled after harvest</td></tr>
<tr><td>Merrimac bdcst after harvest</td><td>Merrimac bdcst at leaf yellowing</td><td>Merrimac bdcst at leaf drop</td></tr>
<tr><td rowspan="4">Rep 4</td><td colspan="3">Caldwell no-till drilled after harvest</td></tr>
<tr><td>Caldwell bdcst at leaf drop</td><td>Caldwell bdcst at leaf yellowing</td><td>Caldwell bdcst after harvest</td></tr>
<tr><td>Merrimac bdcst after harvest</td><td>Merrimac bdcst at leaf drop</td><td>Merrimac bdcst at leaf yellowing</td></tr>
<tr><td colspan="3">Merrimac no-till drilled after harvest</td></tr>
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* plots 10 ft wide, 70 or 210 ft in length, bdcst at 3 bu/a, drilled at 2 bu/a

Figure 33. Lakeland Agricultural Complex - Establishing winter wheat after soybeans

Table 33. Wheat planting dates and soybean planting dates and yield for the wheat establishment study at the Lakeland Agricultural Complex.

Planting date	1991	1992	1993
Soybean	5/13	5/11	5/12
Broadcast winter wheat			
T_1 - at soybean leaf yellowing	8/29	9/17	9/11
T_2 - at soybean leaf drop	9/13	9/24	9/22
T_3 - after soybean harvest	10/22	10/14	10/8
Drilled winter wheat			
T4 - no-till after soybean harvest	10/22	10/14	10/8
Soybean yield (bu/a)	55[1]	52[1]	32[2]

[1] Soybean variety Pioneer 9272
[2] Soybean variety Kaltenberg 241

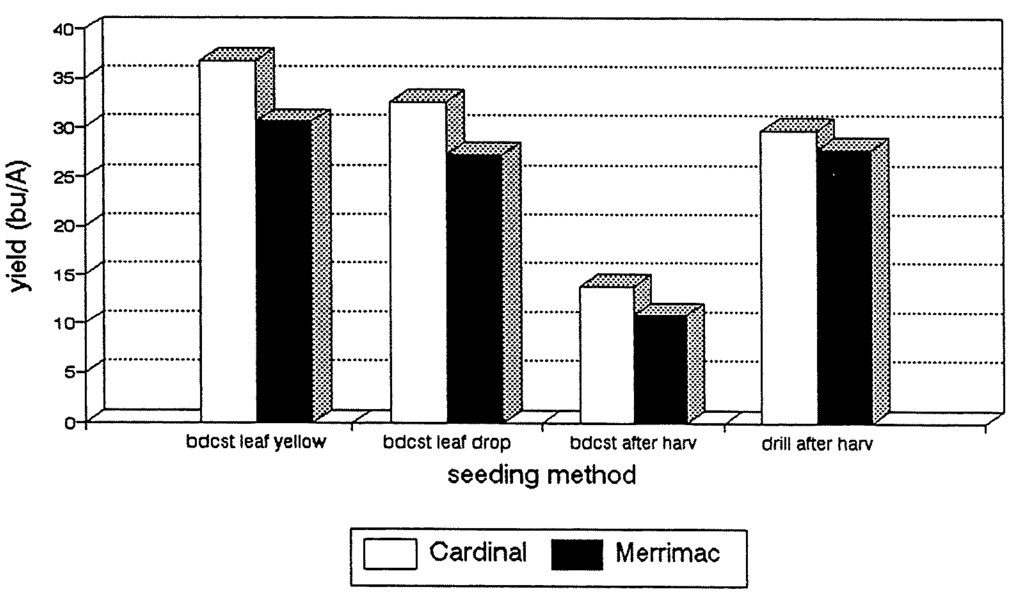

Figure 34. 1993 Wheat Yield by Variety and Method of Seeding - Lakeland Ag. Complex.

VII. A Four Year Gross Margins Comparison of Three Cash Grain Rotations

R.G. Gumz*, W.E. Saupe*, R.M. Klemme*, and J.L. Posner**

The gross margins from a corn-soybean rotation were significantly higher than those from continuous corn in each of the first three years of the cropping systems (rotations) experiments at two sites in Wisconsin. These results are based on 1990-1993 data from "field size" experimental plots at Arlington and Elkhorn, Wisconsin. Corn-soybean returns were also larger than those from a low purchased input corn-soybean-wheat/red clover rotation in both years they were compared. Gross margins from continuous corn and those from the corn-soybean-wheat/red clover system were not significantly different.

The calculated returns from making the transition from continuous corn to either of the other two cash crop rotations resulted in unchanged or increased gross margins.

In this report we describe the long-term Wisconsin Integrated Cropping Systems Trial and then turn to the economic analysis of the results through 1993. The economic analysis is divided into four parts:

- Individual crop enterprise analyses for 1993
- Cropping systems returns for 1990-1993
- Profitability during a transition from continuous corn
- Future directions in analysis and education.

The Wisconsin Integrated Cropping Systems Trial (WICST)

Crop experiments usually focus on one specific crop and generate input and production data for that crop, only. However, there are "rotation studies" that combine information from a number of individual crop experiments, weighting each crop by the number of years it appears in the hypothetical rotation. Those analyses are useful but may not accurately capture the effects the rotation may cause, i.e. the beneficial interactions that can occur among the crops in the cropping sequence that are not measured in the individual crop experiments. For this reason, most economic analyses of cropping systems can only estimate the profitability of the hypothetical rotations.

The weakness in this type of cropping systems analysis is addressed in the long-term Wisconsin Integrated Cropping System Trial (WICST) in which input and production data are collected for all the crops grown in specified sequences. The WICST was created in 1989 by a coalition of farmers from southern Wisconsin and scientists from the College of Agricultural and Life Sciences, Cooperative Extension, Lakeland Agricultural Complex, and the Michael Fields Agricultural Institute.

The trial is located at two sites, the University of Wisconsin-Madison Arlington Agricultural Research Station in Columbia County and the Lakeland Agricultural Complex in Walworth County.

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How the WICST is Unique

The WICST is unique because:

- It focuses on cropping systems instead of individual crops.
- It is conducted using conventional farm equipment.
- Each experimental plot is about 0.8 acre.
- The trial has an expected duration of 12 or more years.
- The trial allows measuring and evaluating environmental effects.
- Farmers collaborated with county Extension faculty, University research scientists, and the Michael Fields Agricultural Institute in selecting which cropping systems to include and in determining what economic analyses would be most useful.
- Response to short term production problems is based on how a farmer would respond, e.g. spot spray herbicide as needed, reseed selected areas, etc.

The combined profitability of all crops in a rotation is addressed by the WICST analysis. The focus is on the profitability of a system of production, i.e. on the entire rotation rather than comparisons between individual crops.

The Three Cash Cropping Systems

Three cash cropping systems were selected for long-term study in the WICST.

Continuous corn is planted in 30" rows in chisel-plowed soil, fertilized with a starter and anhydrous ammonia according to nutrient tests, cultivated once, and weeds and pests controlled with agricultural chemicals as needed.

In the corn-soybean system the corn crop is no-till planted into soybean residue, pests are controlled by chemicals, and 120 pounds N per acre from nitrogen fertilizer are applied. Soybeans are drilled in narrow rows and pesticides applied as needed.

In the corn-soybean-wheat\red clover system the corn receives no commercial fertilizer, is rotary hoed three times and cultivated twice, and has the option of rescue herbicide treatment if needed. Soybeans are planted in wide rows, rotary hoed three times and cultivated twice. They receive no pesticide treatments. During 1990-1992 the winter wheat was aerially seeded into the standing soybeans before leaf drop, and in 1993 it was drilled into the soybean stubble after harvest. Red clover is frost seeded over the winter wheat in March of the following year and takes over as a green manure crop after the wheat is harvested.

Inputs and production data for the four replicates of each crop are recorded by the agronomists, other scientists, and field staff involved with the physical and biological aspects of the trial. For the economic analyses, those physical data are summarized by crop in each system. Appropriate input costs, other related operating costs, value of production, and the gross margins generated are calculated and presented in an enterprise analysis format. The gross margins for individual crops are weighted by the number of years they appear in a rotation to determine the gross margins for each rotation.

Individual Crop Enterprise Analyses for 1993

Analyses for individual crops follow traditional farm enterprise accounting techniques. They include enterprise data on the market value of production (gross returns) and direct (variable) input costs, and permit the determination of gross margins. Gross margins are calculated as the gross returns minus variable costs. Farm products are priced at harvest time on the farm, and storage and transportation costs are thus excluded.

Gross margins represents the returns to the farm's unpaid fixed resources in labor, management, capital, and land. Neither depreciation nor the opportunity cost of owned capital and unpaid family labor and management are subtracted in calculating gross margins. In this initial analysis, it is assumed that a farmer has the equipment, labor, and management to grow any of these rotations. Hence, it is appropriate to use gross margins to determine which enterprise returns the most to the farmer's fixed resources.

The crop enterprise methodology is illustrated in table 34 using the input and production data from the continuous corn enterprise at the Lakeland Agricultural Complex in Walworth County in 1993. The average yield from the four plots (replicates) was 99.7 bushels per acre in 1993. Given a harvest time price of $2.48 per bushel, the continuous corn enterprise generated gross returns of $247.26 per acre.

In all cases, corn yields are corrected for moisture and reported as bushels of No. 2 corn per acre. The price per bushel reflects the discounts in the market place for low test weights, if any. Drying costs are included as a variable cost.

The direct (variable) costs totalled $156.49 per acre, the sum of the physical quantities of each input times its cost per unit. Variable costs included the observed costs of purchased seed, fertilizer, and pesticides; custom operations that were hired, if any; leased equipment, if any; and grain drying. The estimated fuel and repair costs of field machine operations were also included for all machine use from tillage following the harvest of the previous crop through the harvest of the current crop[1]. An imputed charge for interest on the operating capital (inputs) reported in the budget is included, but only for the fraction of the year between incurring the expense and harvesting the crop.

The gross margin is the residual after subtracting the variable costs and represents the returns to labor, management, capital, and land. This was $90.77 for continuous corn grown at the Lakeland Agricultural Complex in 1993 (see table 34).

The gross returns, direct costs, and the gross margins were calculated for each crop in the corn-soybean and corn-soybean-wheat/red clover rotations in a similar manner. These are reported for 1993 in table 35, for both the Lakeland and Arlington research sites. For reference, note that the first line in both sections of table 35 represents the Continuous Corn rotation. In this single crop rotation, the enterprise budget results are also the rotation results.

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[1] These estimated costs are based on the actual field operations and tractors and machinery used on the research sites. However, fuel consumptions and machinery repairs could not be easily measured on the experimental plots and are calculated instead from the Minnesota Farm Machinery Economic Cost Estimates for 1992 for similar size equipment.

Table 34. Costs and Returns per Acre for Continuous Corn System, Lakeland Agricultural Complex, 1993.

Crop and Item	Yield or Quantity	Unit	Price or Factor	Dollars per Acre
CORN:				
Gross Returns				
Corn @ 15.5% moisture	99.70	Bu.	$ 2.48	$247.26
Direct Costs				
Seed (Pioneer 3563)	0.40	Bag	74.22	29.69
Anhydrous	183.00	Lb.	0.11	19.22
Starter (4-10-10)	180.00	Lb.	0.05	9.54
Confidence (Lasso)	2.00	Qt.	5.44	10.88
Extrazine	2.50	Lb.	3.92	9.80
Counter	10.00	Lb.	1.81	18.10
Buctril	1.00	Pt.	5.97	5.97
Drying 2¢ per point (from 22.3%)	99.70	Bu.	--	21.38
Fuel	8.18	Gal.	0.74	6.05
Repairs	1.00	$	17.00	17.00
Interest on operating capital	147.63	$	0.06	8.86
Total Direct Costs				$156.49
Gross Margin for Corn				$ 90.77

* Crop enterprise budgets for each crop in rotations one through five at both Arlington and Lakeland are presented in appendices X.A & B.

The analysis pertains to gross margins for crop production only through harvest, with crops valued at harvest time prices on the farm. To that point in the farm business the production practices, costs, and gross margins are the same regardless of the producer's ultimate disposition of the crop. Analysis of producer's options for feeding the crop to livestock on the farm or for the timing and place of sale off the farm have not been included in the study to date.

Table 35. Costs and Returns per Acre for Crops Grown in Three Rotations at the Arlington Research Station and Lakeland Agricultural Complex, 1993.

Location and Rotation	Crop	Yield Bu. per Acre	Dollars Per Acre Gross Returns	Direct Costs	Gross Margins
Arlington Research Station:					
Continuous Corn					
	Corn	123.8	$306.90	$156.69	$147.21
Corn-Soybeans					
	Corn	129.8	321.97	166.49	155.48
	Soybeans	52.8	331.95	73.02	258.94
Corn-Soybeans-Wheat					
	Corn	87.1	216.01	92.05	123.96
	Soybeans	53.3	335.26	33.98	301.28
	Wheat*	28.6	151.78	76.20	75.58
Lakeland Agricultural Complex:					
Continuous Corn					
	Corn	99.7	$247.26	$156.49	$90.77
Corn-Soybeans					
	Corn	101.2	250.98	125.40	125.58
	Soybeans	49.0	308.21	66.38	241.83
Corn-Soybeans-Wheat					
	Corn	77.7	192.76	74.25	118.51
	Soybeans	32.3	203.01	39.41	163.60
	Wheat*	22.3	172.57	81.71	90.85

* Due to the poor wheat stands at both sites in the spring of 1993, the red clover underseeding flourished. At the time of wheat harvest the cutter bar was set high to avoid the red clover, and once the grain harvest was completed the straw and red clover were cut for beef cattle feed. Gross returns includes 1.4 tons of wheat straw and red clover at $50 per ton at Arlington and 2.2 tons of wheat straw and red clover at $60 per ton at Lakeland. Later, the red clover regrowth was plowed down as green manure for the subsequent corn crop.

Cropping System Returns for 1990-1993

The crop enterprise analysis and cropping system analysis are identical in the case of continuous corn, as the cropping system consists of a single enterprise—corn. The other rotations in the WICST contain two or more crops, and they are managed in the same way they would be on a farm. That is, with the corn-soybean system, half the cropland is in corn and half in soybeans each year. One-third of the cropland is in corn, one-third in soybeans, and one-third in wheat each year in the corn-soybean-wheat/red clover system.

Crop enterprise data have now been collected and analyzed for four years. Crop yields and rotation gross margins are summarized for the three cash cropping systems for all four years at both research locations in table 36. Because of the need to establish each rotation, continuous corn data were available beginning with the first year of the study, corn-soybean rotation data after the second year, and the corn-soybean-wheat/red clover rotation data after the third year. To validly compare the gross margins of the three rotations, only data from the years in which all crops in each rotation were grown can be used, i.e. data for 1992 and more recent years.

1992-1993 Results at Arlington The data for 1992 and 1993 are averaged in the last column of table 3. The system gross margin for the corn-soybean rotation at the Arlington Research Station (Columbia County) site for 1992-1993 was $172.51 per acre, the mean of $137.81 in 1992 and $207.21 in 1993. This compares to the 1992-1993 gross margins of $123.39 per acre for continuous corn and $129.88 per acre for the corn-soybean-wheat/red clover rotation.

1992-1993 Results at Lakeland Agricultural Complex At the Lakeland Agricultural Complex site in Walworth County the average gross margin for continuous corn was $76.64 in 1992-1993 and the average for the corn and soybean rotation was $191.98. The average gross margin from the crops in the corn-soybean-wheat/red clover rotation was $108.03 for the two years.

Table 36. Crop Yields and Rotation Gross Margins per Acre for Three Cash Cropping Systems at the Arlington Research Station and Lakeland Agricultural Complex, 1990-1993.

	1990	1991	1992	1993	Avg. (92-93)*
Arlington Research Station:					
Continuous Corn					
Corn Yield	165.8	160.0	144.1	123.8	133.9
Mean Gross Margin	$270.27	$228.20	$99.56	$147.21	$123.39
Corn-Soybean					
Corn Yield		184.7	150.4	129.8	140.1
Soybean Yield	56.7	60.4	48.5	52.8	50.7
Mean Gross Margin		$267.79	$137.81	$207.21	$172.51
Corn-Soybeans-Wheat/Red Clover					
Corn Yield			99.2	87.1	93.1
Soybean Yield	52.4	59.2	38.0	53.3	45.7
Wheat Yield		63.6	45.2	28.6	36.9
Mean Gross Margin			$92.82	$166.94	$129.88
Lakeland Agricultural Complex:					
Continuous Corn					
Corn Yield	163.6	121.2	119.1	99.7	109.4
Mean Gross Margin	$207.43	$157.09	$62.47	$90.80	$76.64
Corn-Soybean					
Corn Yield		144.7	126.3	101.2	113.7
Soybean Yield	52.8	58.7	46.9	49.0	48.0
Mean Gross Margin		$220.47	$137.45	$183.71	$160.58
Corn-Soybeans-Wheat/Red Clover					
Corn Yield			73.0	77.7	75.3
Soybean Yield	54.3	51.6	51.9	32.3	42.1
Wheat Yield		32.1	25.7	22.3	24.0
Mean Gross Margin			$91.74	$124.32	$108.03

* The purpose of the average is to compare rotations for the years in which all crops were grown in all rotations, i.e, in 1992 and 1993.

Variability Among the Years In addition to providing information for comparing the mean gross margins of the rotations, the long-term nature of the WICST rotation studies also provides insight into the variability in gross margins over time. However, only the 1992 and 1993 data are appropriate for comparing variability among all three rotations. While the corn-soybean system can be compared with continuous corn for the three years of 1991-1993, that is still probably too short a time span for definitive statements. The results so far are of interest, but may not be conclusive (table 36 and figure 35).

Profitability During a Transition From Continuous Corn

Farmers considering a shift from continuous corn or a rotation in which corn predominates, to a system that rotates crops, need to consider the effect of the transition period on gross margins. For example, it takes two crop seasons to switch from continuous corn to a corn-soybean rotation and three years for the transition to a corn-soybean-wheat/red clover rotation.

The examples presented here provide information for farmers that are considering a shift from continuous corn to a cash crop system that includes soybeans, or a system that includes soybeans and wheat. The analyses are based on the four year total of gross returns per acre for three hypothetical farms, each following different alternative cash cropping strategies. To the extent that there would need to be a net increase in capital resources such as machinery because of the transition to a new rotation, gross margins reported here will understate the costs and overstate the returns from the new rotation.

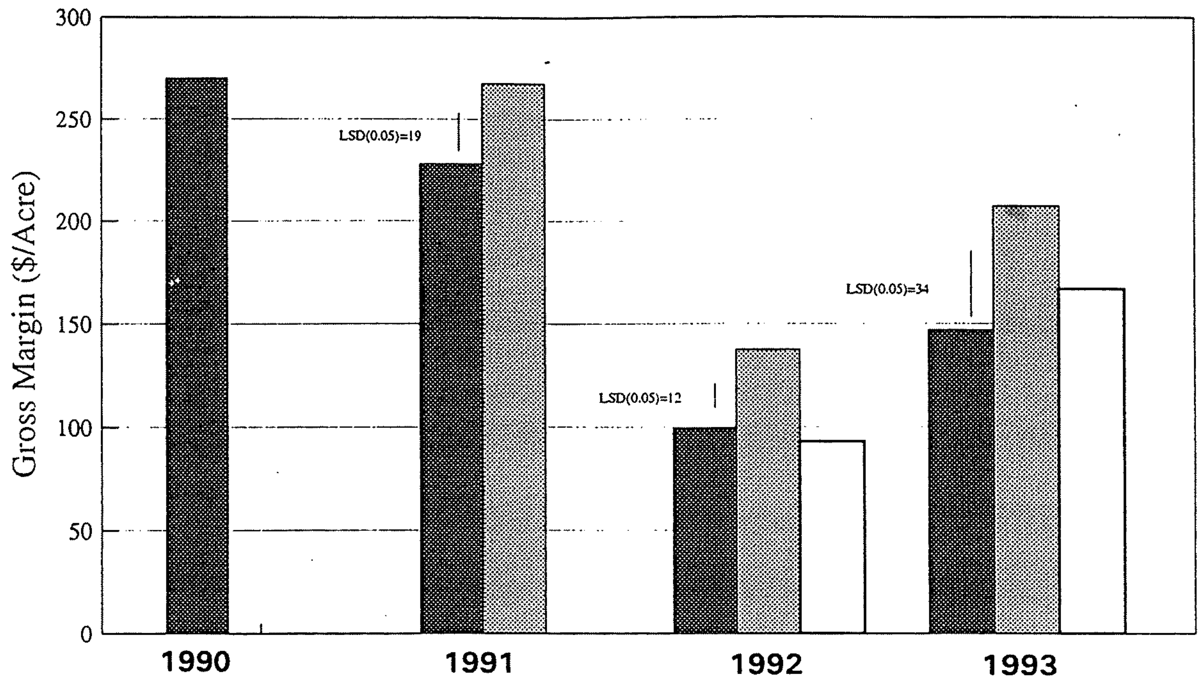
The transitional effects, calculated from the WICST experience, are presented in figure 36. The information in the upper panel is based on data from the Arlington site and in the lower panel from the Lakeland site. The vertical divisions, starting from the bottom, represent the years 1990-1993. The labels on each year show the proportion of the farm's cropland planted to each crop.

In the examples, each farmer starts from a system of continuous corn, with 1990 being the first year of any transition. The first bar graph represents the four year experience of a farmer that maintained the continuous corn system. All cropland would be in continuous corn each year during the 1990-1993 period. The four-year total gross margins per acre for that farmer would be $745 using data from the Arlington site, reflected in the height of the bar graph.

The second hypothetical farmer plans a shift into a corn-soybean rotation. In 1990, half the farm would be in soybeans (following corn the previous year) and the other half would be in corn, a continuation of the continuous corn system of the past. In 1991 half the farm would again be in soybeans, following corn the preceding year, and the other half would be in corn following soybeans the preceding year. That is, in 1991, this farm would be established in the new corn-soybean rotation. The four-year total gross margins per acre for that hypothetical farmer would be $888 based on the Arlington data.

In a similar manner it would take three years for the third farmer to make the transition from continuous corn to the corn-soybean-wheat/red clover system. The new rotation is in place for only the last two years of the 1990 to 1993 period. The four year total gross margins per acre for this system was $742 based on data from the Arlington trial. Note that in 1991 the corn is still corn following corn.

Arlington



Lakeland

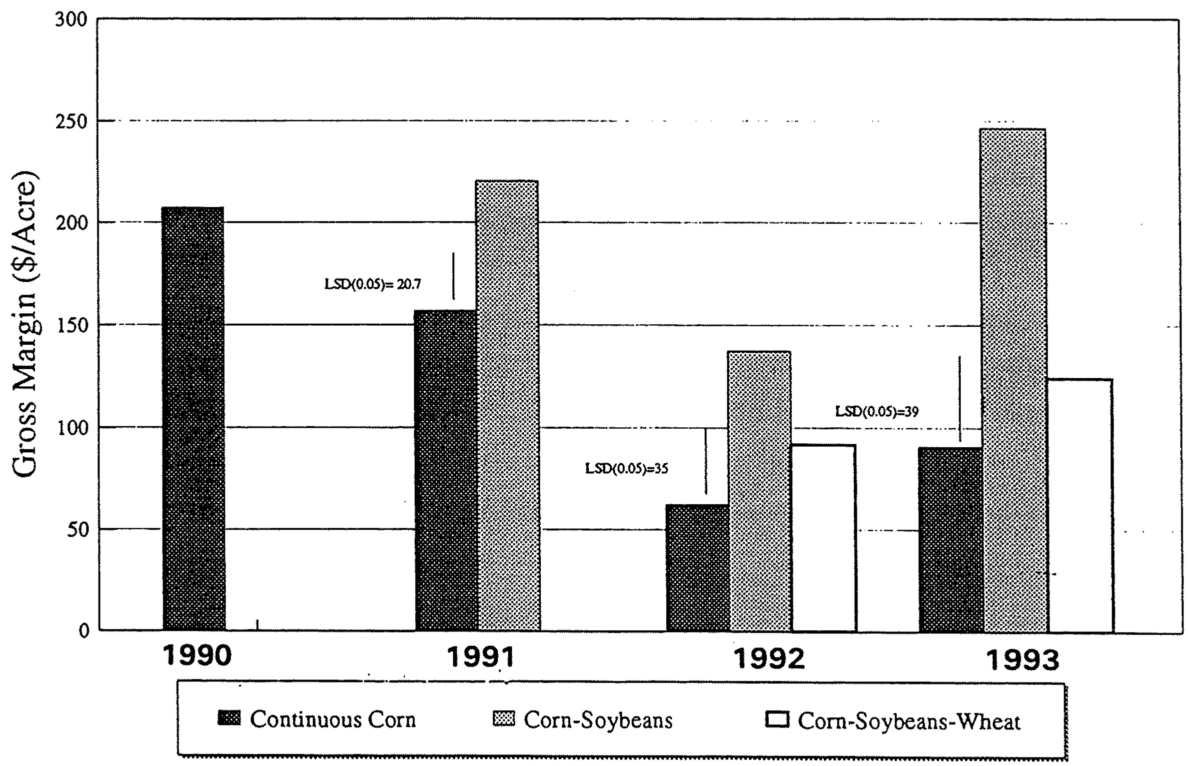
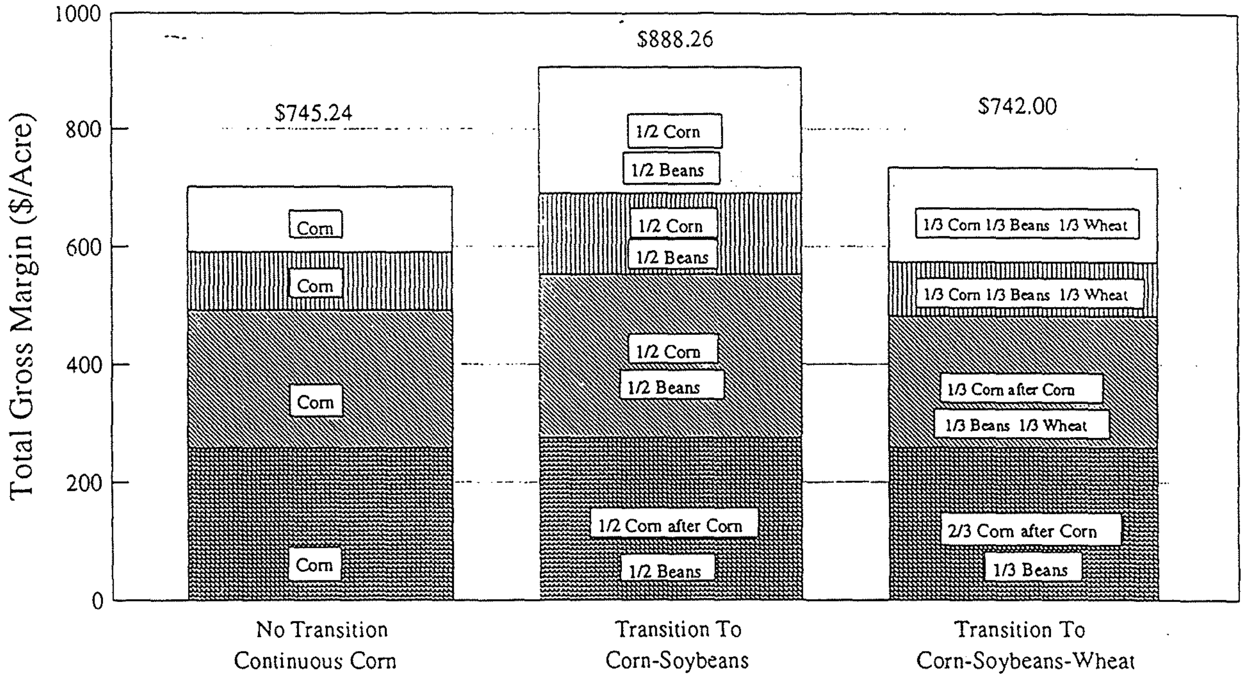


Figure 35. Rotation Gross Margins by Year, Arlington Research Station and Lakeland Agricultural Complex (Gross Margins per Acre)

Arlington



Lakeland

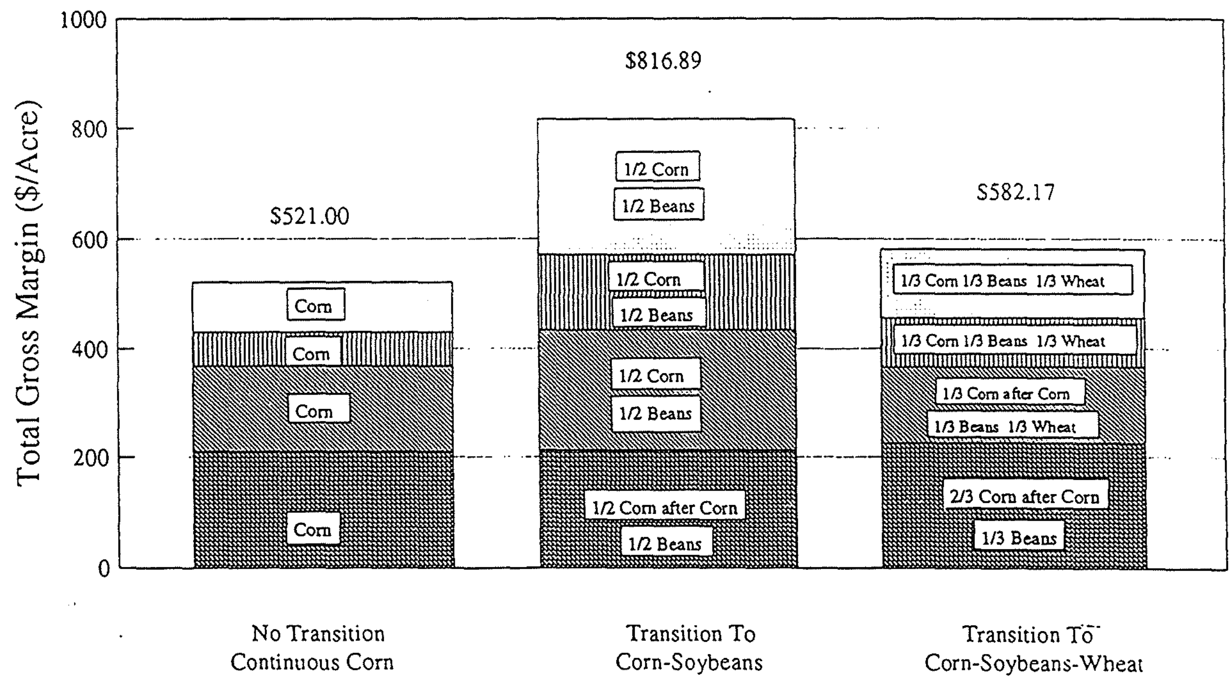


Figure 36. Transition from Continuous Corn, Arlington Research Station and Lakeland Agricultural Complex (Total Gross Margins per Acre for Four Years, 1990-1993)

Results from both WICST locations show similar patterns and indicate that farmers switching from continuous corn to the corn-soybean rotation would gain substantially in gross margins during the four year transition period. Switching to the corn-soybean-wheat/red clover rotation results in gross margins similar to continuous corn over the four year period, but note that the new rotation is in place only during the last two of those four years. As noted earlier, more years of data are needed to make definitive statements about differences among the cropping systems.

Forage Based Rotations

The WICST project also has three forage-based crop rotations: a four year rotation with three years of alfalfa followed by corn (Rotation 4), a three year rotation with oats/alfalfa and alfalfa followed by corn (Rotation 5), and a pasture-based, rotational grazing system (Rotation 6). The crops grown in the first two are mechanically harvested for dairy herd feed. Rotation 6, on the other hand, has been grazed by dairy heifers beginning in 1992 at Lakeland and in 1993 at the Arlington site. Like the three cash crop rotations, the forage based rotations were established in sequence starting in 1990. Because Rotation 4 and Rotation 5 are four and three year rotations, respectively, 1993 was the first year in which all crops were grown in both rotations.

The economic analysis of the forage based rotations is more complex than for the three cash crop rotations where all products are harvested, local markets exist, and cash prices are known for inputs and products. Input and yield levels for Rotations 4 and 5 are relatively straightforward. However, alfalfa is not typically grown as a cash crop and market prices are less well established. In the pasture-based system (Rotation 6), the yield has been measured as the weight gained by dairy heifers during the grazing season. Per acre gains were 948 and 751 pounds at Lakeland in 1992 and 1993, respectively, and 602 pounds at Arlington in 1993. [2] Currently, the gross margin for the pasture-based system is based on the value of the weight gained less all other direct costs. Detailed analyses will be reported after obtaining additional data during 1994.

In order to provide an initial economic analysis for Rotations 4 and 5, we used observed yields and input levels, harvest time corn price, and a price for alfalfa based on its quality characteristics and suitability as fed to a dairy herd with an average milk production of 75 pounds per day. Alfalfa hay with a Relative Feeding Value (RFV) of near 100 based on its protein and fiber content had a ten year average price of about $75.00 per ton in this area. With that as a benchmark, the quality (based on protein and fiber) of alfalfa hay harvested from the plots in 1993 had feeding values ranging from $18.50 to $87.25 per ton.

The initial economic analysis for 1993 indicates that the three year rotation of oats/alfalfa-alfalfa-corn had a slightly higher gross margin per acre at both sites despite having a lower average corn yield. The combination of slightly lower direct costs per acre and higher average alfalfa yield contributed to the slight gross margin advantage.

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[2] The grazing season at Lakeland was 167 days in 1992 (April 30 to October 14) and 152 days in 1993 (may 8 to October 7). At Arlington the season was 137 days in 1993 (may 15 to September 29).

Future economic analysis of the forage based rotations could involve a number of alternatives to balance feed production from the rotations with the dairy herd's needs and determine the value of the fed crops, particularly alfalfa. For example, 25 percent of Rotation 4 is used for corn. Rotation 5, with its 3-year rotation, has one-third of its land producing corn. Rotation 6 produces no corn, requiring purchases to balance the dairy cow's ration. Because the rotations produce different proportions of grain and forage, any comparisons for dairy herd analysis will require ration balancing and purchase of differing proportions of grain and protein.

The pricing alternatives being considered for alfalfa include systems that are based on a) the quality characteristics of the harvested alfalfa, or b) the alfalfa's value as fed to a typical dairy herd. In addition, the effect of each of three forage based rotations could be simulated in association with a dairy herd. Such approaches would be helpful in accounting for the costs of other inputs used in dairy production and in developing an appropriate value for alfalfa.

Future Directions in Analysis and Education

The future direction of WICST analyses and issues will continue to be addressed in the advisory sessions held with farm, academic, and environmental groups and gleaned from feedback at field days. In addition to the analyses of the trials, another important objective of WICST is the dissemination of project results in a useful way to a range of audiences—farmers, environmentalists, policymakers, urban consumers, students, and others. Examples of future work are reported below.

Additional Economic Analyses Feedback from the farmers, Extension Agents, and others involved in the evaluation have shaped the economic analysis process. Most of the suggestions concerning economic analysis from the evaluation meetings with farmers have been included in the analysis, including using harvest prices to calculate total crop value, using gross margins as the key profit indicator, using commercial interest rates, and examining the rotations from a system's perspective.

Other economic issues remain more elusive and require further discussion. These include pricing the forage crops raised in the ruminant livestock rotations, valuation of cattle manure produced in those rotations, developing a process for determining environmental costs, valuation of unpaid family labor, and the consequences of crop diversification regarding the size and diversity of the farm machinery set.

Sources of Variation in Gross Margins With each additional year of data, a more complete economic analysis of the WICST information can be made. For example, wide variation in gross margins between years has already been observed. However, valid comparisons about which rotations have the least variability and which have the most variability will require several more years of data. Also, it may require more than one cycle through a rotation for all the "rotation effects" to be observed.

Differing Environmental Impacts The WICST include data collection that in the longer run will provide information about the differing environmental impacts across systems in terms of soil erosion and movement of fertilizers and pesticides through the soil. Finally, as the study progresses there will be additional data that will permit increased reliability in addressing the transition from continuous corn to alternative cash crop rotations.

VII. EVALUATION STUDIES

A. WICST Mid-term Situational Analysis

L. Forest and P. Dietman*

I. Introduction

The Wisconsin Integrated Cropping Systems Trial (WICST) was initiated in 1989 with the goals of 1) determining the most sustainable and profitable farming system with least impacts on natural resources, 2) the pros and cons of each system, and 3) educating many diverse clientele audiences about the project results and the systems. WICST's major funding was from the Kellogg Foundation but substantial resources, in terms of staff, physical facilities ideas, supplies, and budget, have come from the UW College of Agriculture and Life Sciences, Walworth, Columbia, and Dane Counties, Wisconsin's Department of Natural Resources, Wisconsin's Department of Agriculture, Trade and Consumer Protection, Wisconsin's Fertilizer Council, Pioneer Seed, and Michael Fields Agricultural Institute.

Because of the intended high joint ownership of the project, its long term nature, and the need for continued resources and support beyond the duration of the Kellogg grant, a relatively small number (N=76) of UW CALS, and UW-Extension staff were interviewed in early 1994 to determine what they knew about the project and its goals and methods, and to determine their attitudes about the project's current and future success. This report is a brief summary of some of those interview data.

II. Interview Respondents

76 persons were interviewed. Included in this group were 15 administrators (9 CALS and 6 UW Extension) and 61 UW CALS faculty as follows:

Administration	- 15
Agronomy	- 9
Entomology	- 9
Soil	- 11
Ag Economics	- 3
Rural Sociology	- 4
Plant Pathology	- 5
Ag Engineering	- 3
Continuing & Voc. Ed.	- 3
Horticulture	- 5
Ag. Journalism	- 1
Dairy Sci.	- 6
Meat and Animal Sci.	- 2

* Professor emeritus and graduate student, Dept. of Continuing and Vocational Education, Univ of Wisconsin, Madison.

These persons were not randomly selected but instead were selected on their likelihood of knowing about the project. No generalization is suggested beyond this group. It is the belief by the investigators that almost all persons knowledgeable about WICST were interviewed except for some unavailable persons at the time of the interviews.

III. Results

A. Familiarity

55 or 72.4% of the 76 persons were familiar with or aware of WICST. This percentage regarding awareness, must be interpreted as an artifact. If only those working with WICST were interviewed, the percent would be 100%. If a larger number or a random sample of CALS faculty were interviewed, the percent would go down. In other words, the N of 55, could hypothetically be part of any population, the percent of awareness varying according to the population under consideration.

The N of 55 however, is a fairly reliable and useful finding at this time. It is safe to suggest that 55 to 60 persons among UW Madison and Madison based Extension staff are familiar with WICST. **These 55 who said they were aware of WICST are the base for the analysis and comments that follow.**

Knowledge of WICST (N=55)

Type of Knowledge	Knowledge Level		
	Poor	Average	Complete
General Knowledge of WICST	21	21	13
Knowledge of WICST Goals	17	22	16
Knowledge of WICST Methods	26	22	7
Knowledge of WICST Organization	23	20	12

Comment: Even though the WICST project is large, funded by a large Kellogg grant, involves an unusual or new approach, is multidisciplinary, and therefore could be expected to generate wide spread awareness in five years, it has not done so. Of the 55 who are aware, only about 1/3 (about 10-15 persons) of those could be said to have complete knowledge of the project, its goals, methods, and management. Several persons who were initially involved are not presently involved, and their interest and knowledge is waning. The 10-15 persons who have complete knowledge etc. possibly represent about one staff per department or office. As such these key knowledgeable and committed persons are each a very small minority within their home base, not a particularly strong position for them, when it comes to recognition, reward, merit, promotion and diffusing the idea of multidisciplinary research in their own department.

B. Perception of WICST New and Intriguing Ideas.

The 55 interviewees were asked what they particularly found intriguing or interesting about WICST. The most common categories of responses are shown below.

Intriguing Ideas (N=55)	N	%
Farmer Involvement and Local Input	21	38
Comprehensive evaluation of different systems	15	28
Long duration, and year to year comparison	14	26
Interaction among disciplines	12	22
Sustainability	11	20
Credibility of large plots and large scale	11	20

Eight of those interviewed had no comments. Other ideas mentioned were adult, extension and youth activities and demonstrations and recommendations, visibility and tolerance of new ideas, public relations for critics, environmental perspective, and the many specific disciplinary foci on dairy, economic analysis, weed studies, soil health erosion, and water involvement.

Comment: None of the above ideas are truly new but nevertheless the combination of these ideas in one project might be. WICST staff need to consider all of these ideas in total in explaining the project to others and in gaining awareness and understanding of its uniqueness and advantage.

C. Perceived Disadvantages or Pitfalls of WICST

Pitfall	N	%
Lack of rigor, focus and scientific design	12	22
Financing and future support	10	18
Soils fertility and nutrient levels	10	18
Personnel turnover, follow through and sustaining long term focus	9	16
Cost and time required to get meaningful results	7	12

Other pitfalls mentioned several times were constraints by sustainability groups and a need for proper systems analysis.

Comment: WICST needs to understand these negative perceptions and include and allow discussion of these ideas when presenting project results to faculty and administrators not involved in project.

D. Criteria for Evaluating WICST Success.

Opinions about the value of this project varied greatly. While some of the 55 interviewed were enthusiastic about WICST and felt it was very important for the university to be doing this type of interdisciplinary research, others saw it as a less valuable expenditure of limited time, energy and money. For the WICST project to be continued, it will need to be judged/evaluated positively by the stakeholders interviewed in this project plus other crucial stakeholders. WICST i.e. needs to show it is worth continuing. For these positive judgments to occur in the future, WICST staff need to know the criteria these many stakeholders will be using to make judgments on support. Listed below are the most common criteria mentioned.

Criteria	Frequency
Project leadership, process and coordination	9
Project summaries and publications	14
- User friendly	
- Answer big question	
- Scientific journals	
Used in education/extension	8
Adoption of ideas and practices	36
- By farmers	
- By academia	
- By communities	
Impact, make a difference	13
Funding continued, sustained	13

Comment: Many other evaluation criteria were given along with many specific interpretation of the above general criteria. Project staff must understand these criteria, have them ingrained in their minds, and then relate discussions of project to these criteria. More importantly, project leadership and staff need to focus project to achieve these criteria over next 2-5 years so that when eventual summary follow up evaluations are done, the project meets these criteria.

IV. Recommendations

Reviewing the current knowledge and awareness of the WICST project, attitudes, and suggested criteria for judging eventual success, of the 55 persons who were aware of the project, we are proposing the following action steps. WICST leadership and staff should consider and act on these steps in the next 2-5 years in addition to the current positive steps they are already taking:

1. Develop more media material (leaflets, news articles, radio spots, newsletters, brochures, videos, etc.) that can be used in educational programs by extension agents, CALS faculty, cooperating groups and agencies to explain and illustrate WICST goals, methods and its accomplishments.

2. Approach each CALS administrative unit, faculty department, and extension leadership to update them in face-to-face discussions on WICST goals, methods and accomplishments. Discussion should relate to interdisciplinary research, rewards, recognition systems, criteria for WICST success, and building collaboration.

3. Reclarify and/or reaffirm goals and evaluation criteria for WICST staff. This should begin by reviewing the detailed answers from the 58 stakeholders interviewed in this study.

4. Reclarify strategy, and reaffirm direction of total WICST project toward meeting the goals and criteria as determined in this study.

5. Provide more direct linkup to UW Extension system, leaders and agents so that project results and description will flow into that system for dissemination. Training of the Extension staff should be more planned and explicit in the next several years. Extension publication should now be planned and developed to be used by Extension system.

6. Plan to carry out related followup evaluations of publications, outreach, adoption and impact.

B. Follow-up Survey of WICST Outside Auditors

Richard Powers*

Introduction:

When the founders of this project got together in 1988, it was partly in response to a feeling of conflict and antagonism in the rural community in regard to the environmental effects of traditional agriculture and the merits of what was being called "sustainable ag". While people were choosing up sides on the issue, the WICST founders and the Kellogg Foundation were interested in bringing people of divergent views together and hoped that interaction could bring more harmony in the rural community so that people could work more smoothly together in charting agriculture's future.

The plan was for WICST research projects to supply missing information, and the demonstration sites and events to help diffuse the technical results. Agricultural Journalism graduate student Benami Bacaltchuk's task was to record how much various groups in the rural community know about sustainable agriculture, how they feel about various issues, and how they perceive the positions of others in the system. His work sets the pattern for subsequent surveys to determine whether the project changes people who participate in it.

In 1992, the extension agents from the two sites submitted a list of approximately 160 rural leaders who could serve as "Outside Auditors" to the project. It was envisioned that the changes in attitudes of these people would be a measure of the impact of the education program of the two Learning Centers. An oral survey was administered to 132 of these people between July and August, 1992.

In this second year of the study, a follow-up written interview was sent to this same group of people and 119 responded (86% return rate). The first survey provided statements regarding the seriousness of 13 problems facing agriculture, the extent of support for four pieces of pending legislation plus a question about removing all farm programs, and the extent of agreement to 10 statements setting forth positions on sustainable agriculture. In the second interview (Figure 37) the respondents were asked to check their own positions on 4-point scales (strongly agree to strongly disagree for the statements, strongly favor to strongly oppose for the legislation, very serious to nothing-to-worry-about for the problems). Then each respondent had to say where he thought others would place their marks on the same scales. The "others" were farmers, ag-business, policy-makers, and educators.

With this data we could look at 1) the extent of agreement among these groups on these problems, issues or pending legislation, 2) each group's perception of how well other groups agree with them, and 3) the accuracy or degree of misconceptions.

The major contribution of the evaluation has been to reveal where there is false consensus -- items on which farmers and educators for example think they agree upon but which in fact they do not. Or just as important is to discover previously unrecognized agreements -- where groups actually hold similar positions but don't know it. This kind of knowledge

* Professor, Dept. of Agricultural Journalism, Univ. of Wisconsin, Madison.

1. First, I'd like your impression of how you and each of these groups view some farming problems. Naturally, none of us can accurately read another person's mind, but try to make your best possible guess of a "typical" group member's opinion and mark it with X or a check (check only one per row).

a. PROBLEM : Soil erosion in Wisconsin.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

b. PROBLEM : Soil erosion in Corn Belt.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

c. PROBLEM : Surface water contamination.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

d. PROBLEM : Ground water pollution.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

e. PROBLEM : Pesticide residues on food.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

f. PROBLEM : Government policies.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

g. PROBLEM : Prices of farm products.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

h. PROBLEM : Credit.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

i. PROBLEM : Prices of things used in farm production (inputs).

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

j. PROBLEM : Prices of farm equipment.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

k. PROBLEM : Cost of farm labor.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

* **Farmers** include part-time farmers, retired farmers, farmer's spouses.
Educators include government agency personnel, extensionists, researchers, and environmental spokespersons or activists.
Agribusiness persons include farm financial agency persons and farm consultants, as well as dealers and service persons.
Policy-makers include elected government officials, organization officers and such.

Figure 37a. WICST Second interview (written) - pg 1-2

l. PROBLEM : Net farm profit.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

m. PROBLEM : Outsiders' perceptions of farmers and farming.

	Serious Problem	Large Problem	Some Problem	No Problem
Yourself				
Farmers				
Educators				
AgBusiness				
Policy-makers				

2. Now we would like to have your opinion about legislations affecting agriculture as well as how you think other's view the same legislation.

A. Soil conservation plan compliance.

	Strongly Favor	Favor	Oppose	Strongly Oppose	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

B. Wetland preservation policy.

	Strongly Favor	Favor	Oppose	Strongly Oppose	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

C. Set-aside acres program.

	Strongly Favor	Favor	Oppose	Strongly Oppose	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

D. Atrazine Management areas.

	Strongly Favor	Favor	Oppose	Strongly Oppose	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

E. Removal of all farm programs.

	Strongly Favor	Favor	Oppose	Strongly Oppose	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

3. Now, please tell me how do you see the following statements people have made:

A. Sustainable agriculture refers only to practices that reduce use of agricultural chemicals.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

B. Sustainable agriculture is a new way of farming not yet ready for use on the average Wisconsin farm.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

C. Many practices labelled Sustainable are not exotic or uncommon and could be used on most Wisconsin farms.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself					
Farmers					
Educators					
AgBusiness					
Policy-makers					

Figure 37b. WICST Second interview (written) - pg 3-4

D. Modern agriculture causes environmental damages.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

E. Agriculture is too dependent on non-renewable resources like petroleum.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

F. Farming's impact on the environment has been grossly exaggerated.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

G. Farmers should do all they can to get maximum yields and highest possible production.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

H. You can't farm profitably these days without harming the environment.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

I. Farmers should give up some profit in order to conserve the soil and avoid pollution.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

J. Some "old-fashioned" farming methods can yield higher net profit than modern "high-technology" methods.

	Strongly agree	Agree	disagree	Strongly disagree	No Opinion
Yourself	___	___	___	___	___
Farmers	___	___	___	___	___
Educators	___	___	___	___	___
AgBusiness	___	___	___	___	___
Policy-makers	___	___	___	___	___

4. Now we would like to ask you about agricultural activities you have participate since we talked with you last summer.

a. Did you receive any newsletter, folder, or publication regarding the Wisconsin Integrated Cropping System Trial.

1. [___] yes; 2. [___] no; 3. [___] I don't remember.

b. Did you attend any field day, meeting or lecture connected with sustainable agriculture since our visit with you last summer.

1. [___] yes; 2. [___] no; 3. [___] I don't remember.

c. If you answer Yes to question 4a, could you say which specific activity.

[____].

d. If you answer Yes to question 4b, could you say which specific activity.

[____].

FINAL QUESTION: Which of the above groups do you think you belong in?

[__] Farmer [__] Educator [__] AgBusiness [__] Policy-maker

[__] Other (explain):[________________________________].

Figure 37c. WICST Second interview (written) - pg 5-6 can do a great service in drawing a realistic picture of some social tensions between groups.

"At times this picture will be disturbing," Bacaltchuk pointed out, "but other parts of it may suggest that some of us are worrying about disagreements that don't really exist. If they are warned about the discrepancies or informed about their agreements," he continued, "the groups can behave more rationally in their interactions with one another than would be the case when perception accuracies are unknown. This is a step toward harmony in the community, and the WICST project can help it along as one of its educational goals," he concluded.

The WICST project could try to point out these misunderstandings in communications targeted to specific groups, or by having farmers, educators, agri-business persons and policy-makers give testimonies at WICST events on how and why they react to legislative proposals, or their reasons for the attitudes they hold toward the several statements about farming. WICST might even be able to sponsor small projects in which groups could demonstrate their concerns and views for others to see.

Below are some misconceptions revealed in this evaluation:

1. ABOUT ENVIRONMENTAL PROBLEMS

Overall, educators were most accurate in judging the perceptions of the others towards these problems. Agribusiness persons were next most accurate, and policy-makers (the few in this sample) were worst of all. Farmers' positions were overestimated (others thought they would rate problems as more serious than they actually rated them). Agri-business positions were slightly underestimated, while educators and policy-make positions were severely underestimated (they rated the problems as more serious than they were expected to).

2. ABOUT OTHER PROBLEMS

Farmers overestimated their own group's ratings of the seriousness of credit problems, prices of labor and inputs, and new profit. They underestimated the educators' position on all the economic factor scales.

Educators severely overestimated the seriousness with which farmers regard all the economic problems, and they underestimated their own group on most of them.

3. ABOUT LEGISLATION

Overall, ag-business persons were most accurate in their judgements of group favorabilities toward legislative issues, and policy-makers were least accurate (but recall that this is a small and poorly defined group). Farmers' and educators' attitudes were most accurately judged overall.

Farmers and Ag-Business respondents both overestimated policy-makers' favorability toward environmental quality legislation and significantly underestimated educator and ag-business positions.

4. ABOUT STATEMENTS ON FARMING AND SUSTAINABILITY

Over all groups, the most accurate assessments were made for agreement with the statement on the environmental impact of agriculture; the least accurate judgements overall concerned the statements that sustainable concerns only chemicals, that farmers should strive for maximum yields, and that sustainable practices are not exotic. Farmer and ag-business positions were judged most accurately overall. Judgements of these statements were in general more accurate than judgements of positions on legislation and problems.

Farmers overestimated other farmers' agreement about maximizing yields, but were very good judges of farmer positions on all the other items in the anti-farming" set of statements. They overestimated educator and ag-business favorability to the statement that agriculture damages the environment. On sustainable ag, farmers thought their group agreed more than it really did to statements about sustainable concerning only chemicals and that sustainable ag is not ready for use here yet. They had the same misconception about educators, but were very accurate about ag-business persons.

IX. OUTREACH ACTIVITIES

A. WICST Educational Outreach Program 1993 - Walworth County

Lee Cunningham*

As the WICST project grows each year, we find that we duplicate some of the outreach efforts as well as venture into new areas. Because we are building on our efforts over more than one year, this report will attempt to summarize our progress to date. It has also occurred to us that we need to describe the Walworth County Community so readers of this report can better understand the human issues being addressed by the WICST project.

The sustainability of the agricultural industry is being questioned by farmers, local policy makers, the business community, and the general public. The long term survival of agriculture in Walworth County is important to the economic future and environmental safety of all the people who live there.

Sustainable agriculture, as defined by the Walworth County Extension advisory groups, includes agricultural practices which will be profitable, productive and, at the same time, protect the environment. Conservation tillage, efficient utilization of chemicals and the rotation of crops are examples of more sustainable methods that could be incorporated into existing farming systems.

Production agriculture is one of Walworth County's most important industries. Over $100,000,000 are generated annually by approximately 1000 Walworth County farmers. Those dollars help to fuel the local economy and provide over $9,000,000 in property taxes each year. As stated by the Walworth County Board Chairman, Gerald Byrnes, "Agriculture is the industry that shows stability in a county".

Walworth County's total land mass equals 327,680 acres. 75% or 247,113 acres are used for agricultural purposes. The long term environmental changes caused by the farming practices used on those acres will effect all the residents of the county.

The pie chart below portrays the percent of acres each major crop enterprise utilizes in Walworth County. <u>81.9 %</u> of the farm land is used for intensive row crop production where considerable environmental damage can occur if proper management practices are not followed. Row crop production is also responsible for approximately 67% of the annual $100,000,000 of gross sales produced by production agriculture. Walworth County ranks second in soybean production and number 6 in corn production among all counties in the State of Wisconsin. These three factors clearly help to identify where the emphasis of an educational program in sustainable agriculture, as defined by the Walworth County advisory groups, can have the greatest potential impact on the most people in the county.

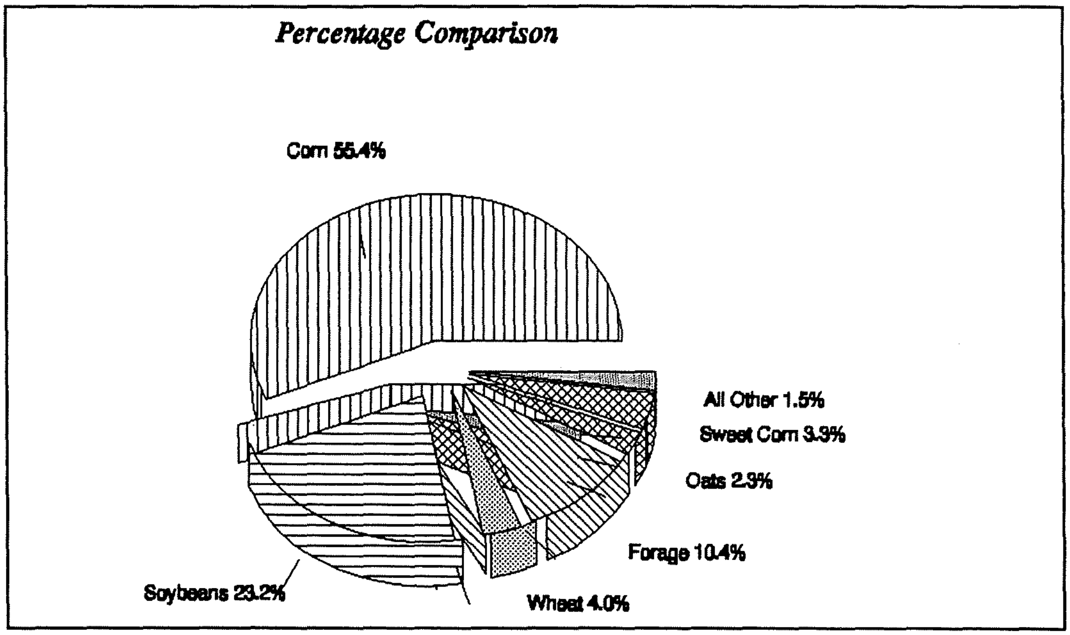
The total population of the county exceeds 75,000 people. As stated previously, only a few more than 1000 of them are farmers. This means that approximately 1.33% of the total population of the county is directly responsible for the proper land use of over 75% of all the land in Walworth County. The power of public opinion in the decision making process of what agricultural technology can be used to produce food, makes it important

* Walworth County UW-Extension Agri/Business Agent

for a sustainable agricultural educational program to include the general public as a clientele group.

A sustainable agriculture system can serve as a model for society to follow in its quest to accomplish the same goal of sustainability. More important is the fact that on a long term basis, if agriculture is not sustainable, society itself will not survive.

WALWORTH COUNTY CROPPING STASTISTICS



Our outreach objectives to date have included the following:

A. <u>Objectives</u>

1. Four hundred Walworth County farmers will begin to choose production practices based on profitability, productivity, and environmental impact.

2. Five farmers will establish sustainable agricultural demonstrations on their farms.

3. Five University Researchers will increase their understanding of sustainable agricultural practices by including these practices in their research.

4. The Walworth County Board will adopt a strategy to support sustainable agricultural practices as defined by the Strategic Planning Committee.

5. The general public will increase their understanding of the sustainable agricultural practices used by Walworth County farmers.

6. Representatives from the Walworth County Agriculture Stabilization and Conservation Service, (ASCS), Soil Conservation Service, (SCS), and the Land Conservation Committee, (LCC) will increase their understanding of sustainable agricultural practices.

B. <u>Clientele</u>

1. Walworth County Farmers
2. Walworth County Elected Officials
3. University Specialists
4. Agricultural Extension Agents
5. Private Agricultural Research Groups

6. General Public
7. High School Agriculture Instructors
8. Local, State, and Federal Elected Officials
9. Local Agribusiness Professionals

C. Subject Matter Taught

1. Introduction of the "Wisconsin Integrated Cropping Systems Trial" (WICST) as a forum for the sustainable agriculture debate and learning.
2. Comparison of cropping rotations
3. Soil characteristics and their effects on the agricultural production system
4. Effects of climate on growing crops
5. Cropping systems as individual economic enterprises
6. Systems approach to farming
7. Historical field data and its significance to a system
8. Variety choice and its suitability to the system used
9. Weed seed proliferation as a consequence of the cropping system used
10. Know your base line soil fertility and monitor it annually
11. Yields, weather and the agronomic calendar
12. Earthworm ecology in agriculture
13. Weed seed monitoring
14. Phosphorous and Potassium nutrient cycling
15. Ground water movement
16. Ground water contamination
17. Water percolation in soils
18. Nitrate monitoring in the WICST project
19. Seed varieties, planting dates and planting rates
20. Estimation of nitrates available for corn production
21. Nutrient budgeting in a farming system
22. Conservation tillage trends in corn and soybeans
23. No-till, Ridge-till and Mulch-till
24. Tillage practices and how they fit in different systems
25. Predicting soil losses due to erosion by different systems
26. Pest control practices using rotations in the systems approach
27. Economics of high and low input rotational systems
28. Walworth County agriculture and its influence on the consumer
29. Protection of the environment
30. Living with your neighbors (urban and rural)
31. The art of communications
32. Agricultural technology advancements and how will we use them
33. Manure and what it is worth as fertilizer
34. Composting
35. Mechanical cultivation - How it fits in a sustainable system
36. Interseeding of alternative crops and the influences on rotations
37. Rotational grazing as a cropping system
38. Team work in a systems approach project
49. Bridging the gaps between farmers, researchers and ag agents
40. The public's stake in sustainable agriculture
41. Wisconsin Integrated Cropping Systems Trial - Learning by doing in an Outside Classroom
42. Soil health evaluation

D. Teaching Methods Used

1. Group Meeting and Field Day presentations

   a. Wisconsin Integrated Cropping Systems Trial Annual Field Day
   b. Rodale Agricultural Institute Annual Update
   c. Michael Fields Organic Agricultural Institute Field Demonstrations
   d. Sustainable Agriculture Field Day Arlington
   e. John Deere Equipment Dealer Field Days
   f. Pioneer Seed Dealer Annual Field Trials
   g. Cultivator Demonstration Day

2. Large Group Activities

   a. Walworth County Fair (WICST tours)
   b. Walworth County Annual Dairy Breakfast (WICST tours)
   c. Annual meetings of DHIA and Holstein Association
   d. Sustainable Agriculture Conference (Wisconsin Dells)
   e. Educational Display presentation at the Ag/Ag-Business annual program planning meeting
   f. Education Display presentation at the Agronomy Society North Central Meeting.
   g. Civic Group presentations (i.e., Kiwanis)

3. Newsletters

   a. "Your Partners in Farm Business" - Joint newsletter with Land Conservation Department, Agriculture Stabilization Conservation Service and Soil Conservation Service (1,450 recipients on a monthly basis.)

4. Mass Media

   a. Local weekly newspapers
   b. Periodic radio presentations
   c. Television (Introduction of the WICST project at the telecast aired at the State Fair
   d. Satellite presentation to 17 states (Food Safety/Sustainable Agriculture)
   e. Feature Stories (Country Today and Agri-View)

5. Personal Counseling

   a. Telephone information/FAX
   b. Farm Visits
   c. Office Counseling
   d. Personal WICST tours
   e. Instructional written correspondence with clients
   f. WICST self-tour information guide

6. Innovative Teaching Methods

a. The development of the Wisconsin Integrated Cropping Systems Trial has been designed around the concept of having an outside classroom to be utilized by a variety of clientele groups. The Wisconsin Integrated Cropping Systems Trial Annual Field Day has been designed with the participants having the freedom to choose what they want to see, where they want to go, and how long they want to stay. By designing the event in this manner the participants have had the real freedom to enter into conversations, discussions and debates with presenters. This atmosphere allows the Wisconsin Integrated Cropping Systems Trial site to be a true forum for the healthy exchange of ideas from the many different agricultural systems philosophies. It has started to open the lines of communication between the traditionally feuding extremes.

E. Results and Evaluation

Objective 1: Four hundred Walworth County farmers will begin to choose production practices based on the profitability, productivity, and the environmental impact of each one.

Four hundred twenty-six farmers have begun to choose production practices based on the profitability, productivity, and the environmental impact of each one through their personal involvement in the sustainable agriculture program events.

Four annual sustainable agriculture field days were held from 1990 through 1993. 534 individuals participated in the 4 events. Exit survey responses from 271 farmers who attended the field days are summarized in table 37.

Table 37: Sustainable Ag Field Day Summary

	% of Farmers Responding Positively		
	1991	1992	1993
Was the field day worth attending?	99%	93%	87%
Do you need to re-evaluate your farming system annually?	51%	63%	99%
Would you use productivity, profitability, and environmental effect to decide what changes you would make?	31%	56%	73%
Will you use the information learned at the WICST project to help make decisions in the future?	27%	91%	97

The change in farmer attitudes is identified by the increase in the percent of positive responses to the questions asked over time.

A survey was conducted annually in 1991 through 1993, at the pesticide certification training sessions. These sessions included teachings about sustainable agriculture practices demonstrated in the WICST project. 281 participants were asked if they would use the three objective 1 criteria; profitability, productivity, and environmental impact, to evaluate their own production practices. Sixty-seven percent stated that they would. When asked if they were going to implement any alternative production practices into their own operations sixty-one percent responded positively. Twenty-two percent said they would make no changes and nineteen percent were undecided.

Conservation tillage can be considered a more sustainable agriculture practice than plowing. The number of acres in Walworth County farm land using conservation tillage practices including no till, ridge till, or mulch till has increased by 125% from 1989 through 1993 (Table 38). This dramatic increase is due in part to farmers contact through WICST sustainable agriculture education events. If an average cost savings of $5/acre were realized by the implementation of these practices, an increase of $228,300 has been accomplished.

Table 38: Change in Conservation Tillage Used

TILLAGE METHOD	1989 ACRES	1993 ACRES	ACRES INCREASE	% INCREASE
No Tillage	3,460	11,650	8,190	237%
Ridge Tillage	480	500	20	4.2%
Mulch Tillage	33,050	70,500	37,450	113%

* 1989-1993 National Survey of Conservation Tillage Practices - An annual survey by the Conservation Technology Information Center, USDA

A telephone survey was conducted in March, 1993 with 30 farmers who had taken part in various Walworth County Sustainable Agriculture events. 21 had changed their personal opinions about the methods they were using to produce crops in the last three years. When asked if their involvement in sustainable agricultural educational events had influenced them all 21 answered "Yes".

15,000 farmers were reached in June, 1993, through a feature story written in "The Cooperator", a Newspaper From Your Cooperative entitled, "Livestock/Cropping Systems Being Evaluated at Lakeland Ag Complex."

A letter written by Greg Blum, Walworth County ASCS Director, emphasized that the change in farmers attitudes to include more than just productivity in their farming practice evaluations was due in part to their involvement in WICST sustainable agriculture education program.

The following case studies are 2 examples of how Walworth County farmers have used profitability, productivity and environmental impact to measure changes they have made in their farming operations. The individuals in these case studies have been involved in a number of the educational events conducted at the WICST site since 1989.

Case Study #1

Farmer A operated a 520 acre crop and dairy farm in Walworth County. Over the last 4 years he has made a number of changes using the three key criteria of profitability, productivity, and environmental impact as his guides.

Prior to 1989 the farm used the following methods to raise crops.

1. Corn, soybean and wheat acres were mold board plowed.
2. Over half of the plowing was done in the fall.
3. Soil tests were used to determine how much commercial fertilizer to apply annually.
4. Spring tillage consisted of two passes with a finishing disk.
5. Both corn and soybeans were planted with a conventional planter. Wheat was sown after the soybeans were harvested.
6. Weed control was accomplished by the use of chemicals and the secondary tillage passes in the spring.
7. The majority of the machinery was owned.

By 1993 the farm has made the following changes.

1. Corn and soybean acres are chisel plowed in the fall leaving crop residue on the soil surface to protect it from erosion.
2. No mold board plowing is done.
3. Soil tests are used to determine if commercial fertilizer is required after proper dairy manure credits have been taken into account.
4. Corn is planted using a no-till planter and soybeans are drilled in 7 1/2 inch rows by a leased no-till drill.
5. A corn, soybean, winter wheat rotation is followed eliminating the need for corn rootworm insecticide.
6. Corn weed control is accomplished by the use of a combination of 10 to 15 inch banded chemical application and mechanical cultivation. Reduced rates of post emergence chemicals are used in some cases on soybeans after specific weed problems of the previous crop have been taken into consideration.
7. Wheat has been sown by aircraft over top of the soybeans prior to leaf drop. This practice eliminated the need for tillage.
8. Clover has been frost seeded into the wheat in the spring of the year. The wheat is harvested as grain and the clover is used as a ground cover and a source of nitrogen for the next years corn crop.
9. The majority of the machinery required is leased from a local dealer.

By implementing these dramatic changes the farm continues to operate with a positive cash flow fulfilling the first criteria of profitability. For example the cost of production of corn has been reduced by $ 12 to $ 13 per acre and the cost of production of soybeans has been reduced by $ 10 to $ 12 per acre by reduced chemical input. Cost savings from reduced tillage, including labor, amounts to $9 to $10 per acre. The gross savings in production costs are approximately $10,800 annually. Savings from leasing equipment rather than the traditional capital investment route has also resulted in approximately $10,000 annual savings. Production has remained at levels comparable to those prior to 1989 fulfilling the second criteria of productivity. The combination of conservation tillage, reduced chemical inputs, close monitoring of the fertilizer needs and crop rotation are attempting to meet the third criteria of environmental safety.

Case Study #2

Farmer B owns and operates over 5000 acres of land. He is considered to be a commercial farmer and an innovator by most of his neighbors. Over the past 4 years his operation has changed by going to no-till planting and reduced chemical application in both soybeans and corn. He has been instrumental in the designing of the Wisconsin Integrated Cropping Systems Trial and has exclusively used the three criteria as he has made major decisions regarding his farming system. He has reduced his average crop production costs by more than $ 9 per acre resulting in a gross savings of more than $ 49,500 annually.

Farm A provides a typical sized model for other farmers to evaluate and farm B provides an excellent model for large operators to evaluate.

Objective 2: Farmers will establish sustainable agricultural demonstrations on their farms.

Five farmers established five sustainable agricultural demonstrations on their farms.

Farmer A's demonstration objective was to make use of the fertilizer value and the soil life enhancing properties of chicken manure by soil testing, yield results, and subjective analysis of the soil health over 5 years. Chicken manure was readily available from a major poultry farm located 20 miles away. The farmer has completed two years of the demonstration and has been pleased with the physical changes seen in the soil. The negative effect of transportation costs on the feasibility of using this material has been realized.

Farmer B's demonstration objective was to compare the yields of 25 to 30 corn hybrids including 5 to 10 food grade corn varieties. The food grade varieties had the potential to increase returns per acre over regular corn varieties meeting the profitability requirement of sustainability but productivity and environmental results were questioned by this agent. This proved to be the areas where the farmer learned the most. The farmer found that white food grade corn yielded less and the handling costs were higher and more difficult to accomplish. The farmer has continued to grow the food grade corn and is investing in the handling equipment needed to reduce kernel damage. The farmer is considering growing food grade white corn without chemical input to meet a niche market demand.

Farmer C's demonstration involved the inter-seeding of hairy vetch and annual rye grass into corn. The farmer wanted to evaluate the ability of the two crops to reduce weed growth and to act as a cover crop. She found that inter-seeding at last cultivation did not allow the cover crop adequate sunlight to produce the volume of bio-mass she wanted in the fall. She has decided to continue to work with cover crops and to make modification in her planting methods.

Farmer D's demonstration involved the growing of popcorn. Alternative methods of corn borer control were to be used and effectiveness compared. By doing the demonstration the farmer found that a mixture of organic materials tested did not work. The farmer decided that popcorn was very difficult to grow. He came to the conclusion that popcorn did have an excellent return per acre potential. The farmer is now considering alternative uses for popcorn as packaging material.

Farmer E's demonstration has evolved into a complete change to a total organic farming system. The farmer has chosen to include rotational grazing and seasonal milking in his dairy enterprise. This agent pointed out that a marketing plan should be included in the farmer's long range plans. The farmer has acknowledged the value of a specialty market and has asked for additional assistance from this agent in that area. The farmer has progressed with the help of this agent and many Extension Specialists. Professional agronomists from the Michael Fields Agricultural Institute have also provided assistance. This project has provided another forum for professionals with varying opinions to become involved with each other and to work on another farming system that has the goal to be sustainable.

Each of the on farm demonstrations proved beneficial to the individual who physically did it. The demonstrations provided additional examples this agent used with other clients that were interested in similar ideas.

Objective 3: Researchers will increase their understanding of sustainable agricultural practices by including them in their work.

Ten researchers increased their understanding of sustainable agricultural practices based on their work with the "WICST" project. The publications included results gained from work done at the "WICST" project site.

The following titles provide examples.

"Legume Cover Crops as an Internal Source of Nitrogen in Cash Grain Systems"

"Weed Management With Reduced Herbicide Use and Reduced Tillage"

"Effectiveness of Substituting Cultivation for Herbicides"

"Developing a Soil Health Report Card"

"Corn-Soybean Compared With Continuous Corn in WICST"

Objective 4: The Walworth County Board will adopt a strategy to support sustainable agricultural practices as defined by the strategic planning committee.

The Walworth County Board adopted a strategy to support sustainable agricultural practices as defined by the strategic planning committee by passing a resolution to change the name of the Walworth County Farm to the Lakeland Ag Complex and by identifying the futuristic purpose of the complex to include the following:

a. To promote a modern image of animal and crop production agriculture to the general public of Walworth County.

b. To provide a place where people can see what modern agriculture is all about.

c. To increase consumer awareness of the quality and quantity of their food supply.

d. To assist the urban and agriculture communities to harmoniously co-exist as Walworth County's population continues to expand.

The Lakeland Ag Complex mission and overall educational goals led to the inclusion of the 100 acre "WICST" project on the farm. It was intended to be an outside classroom which would be available to all the clientele listed in this program.

Objective 5: The general public will increase their understanding of the sustainable agricultural practices used by Walworth County farmers.

1,395 people identified as the general public increased their understanding of the sustainable agricultural practices used by Walworth County farmers through "WICST" site tours given during two Walworth County Farm Bureau Breakfasts held at the Lakeland Ag Complex in 1991 and 1993.

Sixty-eight members of local civic groups like Kiwanis increased their understanding through their participation in presentations made by this agent. The verbal responses from the groups were very positive and this agent has been invited back to give updates on the "WICST" project twice. Twelve members of these groups chose to attend the annual "WICST" field day in 1993 to see the sustainable agricultural practices for themselves. Their responses were included in the exit survey. When asked if the project was worthwhile and should be continued all twelve agreed it should.

Local news articles were received by over 45000 residents of Walworth County. The articles described the sustainable agricultural practices being demonstrated in the "WICST" project.

Objective 6: Representatives from the Walworth County Agriculture Stabilization Conservation Service, (ASCS), Soil Conservation Service, (SCS), and the Land Conservation Committee, (LCC) will increase their understanding of sustainable agricultural practices.

Representatives from the Walworth County Agriculture Stabilization Conservation Service, (ASCS), Soil Conservation Service, (SCS), and the Land Conservation Committee, (LCC), increased their understanding of sustainable agricultural practices through their personal involvement in events at the "WICST" project site.

Additional results:

The acting Dean of the College of Ag Life Sciences, Neil Jorgensen: Associate Dean and Executive Director of the Agricultural Experiment Station, Don Field; Associate Dean and Associate Director of the School of Natural Resources, Gayle Worf; and Dr. Richard Vatthauer, State Program Director University of Wisconsin Extension have attended the "WICST" Advisory Board meeting and have voiced their support for the sustainable agriculture project and its presentation of sustainable agricultural practices.

6,476 individuals have visited the Walworth County WICST site between 1990-1993.

A number of individuals and groups from foreign countries, including 7 from the African continent plus, Japan, Australia, Pakistan, Egypt and Russia have toured the "WICST" with this agent and have entered into lengthy discussions in regard to implementing this type of outside learning center for agriculture into their countries.

This agent was asked to present "The Wisconsin Integrated Cropping Systems Trial -- Agro-ecology and Community Learning -- How it works and what role Extension is playing", at the Agroecology Conference for Michigan Extension Agents in July of 1993.

The Agricultural Stabilization Conservation Service, Land Conservation Committee, Soil Conservation Service Agencies have all written letters of support for the "WICST project. They are also assisting in the planning of 1994 WICST Field events, designed to meet the educational need of their counterparts in other counties.

This agent has been asked to make a second presentation to the Nebraska Integrated Cropping Systems Trial Planning Committee as they plan to use the "WICST" project as a model for their own efforts in sustainable agriculture education outreach in 1994.

Dr. John Hall and this agent have become members of the Sustainable Agriculture Task Force of the University of Wisconsin-Madison. Future planning in the area of Sustainable Agriculture and the role the University and Extension is being addressed at this time.

The WICST sustainable ag program received the Search for Excellence State Program Award at the Wisconsin Association of County Ag Agents Conference in 1993.

Because of the creation of the Integrated Farming systems Network (IFS), by the W.K. Kellogg Foundation and our involvement in it, we have expanded our vision of what we are trying to accomplish through our efforts in the WICST project. The summary of a nominal group activity conducted with the WICST Advisory Group during the 1993-1994 Winter meeting is included here as a very important outreach activity because it gave us a chance to address three key issues identified by the IFS Network.

The three questions posed to the advisory committee and their ranked responses were as follows:

1. List the ways the WICST project can foster change in the attitudes of people who work within Educational Institutions toward sustainable agriculture systems.

   A. Determine issues and needs of farmers and other users where WICST has expertise and use this to communicate with the people working within Educational Institutions.
   B. Allow WICST to serve as a forum for interaction between groups.
   C. Concentrate on in-classroom activities at the Elementary level.
   D. Widen the participation of College of Ag and Life Science and Extension Faculty in the project.
   E. Promote WICST as an example of interdisciplinary and systems approach to long-term research and outreach.
   F. The WICST should cooperate with the Wisconsin Department of Agriculture Trade and Consumer Protection in a joint sustainable agriculture effort.

2. List the ways the WICST project can influence public ag policy.

   A. The WICST project researchers have the obligation to ensure the data is sound and comprehensive.
      a. Satellite studies are necessary.
      b. Incorporate past research.
      c. Develop risk analysis.
      d. Don't release information prematurely.

   B. If A is accomplished, then use the research data to support future legislation at the local/state and federal levels.
   C. Area of possible influence is the environmental groundwater monitoring of atrazine at the Lakeland site.
   D. Local public educational interaction will have grass roots impact on policy.

3. List the ways the WICST project can help to create a vehicle for information exchange.

   A. Develop an internal information network between members of the project.
   B. Create WICST information specialist position within the project.
   C. Target audiences for specific events.
   D. Develop computer software spreadsheets, etc., decision aids.
   E. Develop video's.

A number of other ideas were generated from this exercise and will be considered as the project develops.

B. WICST Educational Outreach Program 1993 - Columbia County

P.D. Ehrhardt *

Interest in a no-till cultivator field day was high despite rainy weather and delaying the activity for two weeks (Table 39.). The morning session consisted of more agency people than farmers; however, the afternoon group consisted of farmers, consultants, and sales agronomists. Support from local dealers and company reps was excellent. Machines spanned the gamut from high clearance "S"-tine machines to heavy-duty no-till models.

Several other groups and field days were repeated from past years, with a variation on the topics. Nutrient and Pest Management (NPM) practices and their application were hi-lighted at the Agronomy and Sustainable Ag Field Days and for the Wisconsin Association of Vocational and Agricultural Instructors (WAVAI) summer conference 'Agronomy/Soils' workshop.

We worked with DeForest 4th grade teachers and the DeForest Agriculture instructor to try to develop instructional units based on the WICST program. We are hoping to initiate tours next fall; however, teachers can take only a limited number of field trips, even if funds from the WICST program could cover the expenses. Educational materials from the Wisconsin Milk Marketing Board, The Wisconsin Agri-business Council and other producer groups was well received by both teachers and students. The teachers were also very receptive to reprints on "Bottle Biology" activities, Wisconsin Farm Bureau's 'Ag in the Classroom' curriculum guide, the curriculum developed by the Walworth County team, and other curriculum guides. The teachers are most interested in getting additional professionally developed materials that are already available. The best use of the educational funds may be to find good quality agricultural teaching aids and materials and making it available for the teachers in the area. (This could include elementary education teachers, middle and high school science and natural resources teachers, and even agriculture/horticulture teachers.) The teachers want the material but don't know where to find it, and if they do, they often lack the money to purchase it.

In general we need to decide "what is our outreach mission?" Limiting our activities to developing materials specific to the WICST project may limit what we can do and may limit how much we can make available to local teachers. The 'biggest bang for the buck' may be to facilitate making quality curriculum, videos, and teaching aids available to the local teachers. Once a strong support base has developed between WICST and the local teachers, we could build WICST specific activities from there.

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* Assistant Superintendent at Arlington Agricultural Research Station.

Table 39. Educational Activity Listing for Columbia County

GROUP OR ACTIVITY	NO. ATTENDING
WICST County Committee walking tour	8
No-till Cultivator Field Day and Demo	65
WAVAI Summer Conference - NPM & No-till topics	22
Sustainable Ag Field Day - Applying NPM Practices	85
Agronomy Field Day - Tour A -- Results from WICST	280
FVTC Natural Resources Program	45
Meeting with DeForest Elementary Ed Teachers about using the WICST program in curriculum	8
Dan Young and High School Science Teachers	20
Politicians from India	4
Individual Contacts Off Site	22
TOTAL	**559**

APPENDIX I. **LIST OF PUBLICATIONS**

1990

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GARLYND, M. J., A. V. KURAKOV, P. A. PORTER, and R. F. HARRIS. 1992 Descriptive and analytical characterization of soil quality/health. American Society of Agronomy meetings. Minneapolis, MN. Nov. 1-6. Agronomy Abstracts p 257.

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APPENDIX II. **Arlington Agricultural Research Station - 1993 WICST Agronomic Report**

P.D. Ehrhardt *

The 1993 growing season was typified by extremes and abnormalities all year long. Changes in management decisions reflected these climatic aberrations.

Alfalfa winter-killed severely for the second year in a row; however, winter wheat over-wintered fairly well. The R5 and younger established R4 alfalfa plots had 20-80% stands with with R5 overwintering slightly better than the later fall cut R4. All the oldest established R4 alfalfa treatments (10% stand remaining) and many of the other treatments would have been destroyed and rotated to a non-legume crop under normal production circumstances, However, to maintain the proper rotational sequence for the trial, poor alfalfa stands in R4 and R5, were renovated with a grass/legume mix on April 28, 1993 with a John Deere 750 no-till drill. Perennial rye grass (Parana @ 5#/acre) and red clover (Arlington @ 6#/acre) was no-till interseeded into entire or damaged sections of plots that will be rotated to corn next year, while perennial rye grass (Parana @ 5#/acre) and alfalfa (Magnum III @ 8#/acre) was no-till interseeded into R4 plots requiring another year of alfalfa production. The interseeded clover and rye grass established and grew well. The stand vigor increased with progressive cuttings, and would probably yield very well in the second year. The interseeded alfalfa looked good early, but by the second cutting it was hard to find any young alfalfa plants. From this experience and attempts at interseeding alfalfa in production fields at Arlington, it is clear that unless the established alfalfa is completely killed, interseeding weak alfalfa stands with alfalfa is not a recomended strategy to rescue a damaged alfalfa stand.

Pastures over-wintered better with stands ranging from 75-95%. As part of the on-going pasture renovation strategy and to fill in areas where plants were sparse, the pastures were frost seeded with 12#/acre Arlington red clover on April 9, 1993.

Alfalfa harvesting was delayed and the total number of cuttings was reduced due to interseeding the plots, combined with above average precipitation. The oats/alfalfa, R5/T11, was harvested for grain on August 11, but the regrowth was not harvested. The direct seeded alfalfa, R4/T10, was harvested on July 14 and September 1. All established treatments, R5/T13, R4/T8, and R4/T9, were harvested June 10, July 12, and September 1.

Winter wheat in the WICST trial again displayed the rowed pattern of a full stand on the tops of the old soybean rows, and a reduced or no stand in the valleys. In 1993, the soybeans were cultivated with a Brillion danish tined cultivator. This resulted in only a one or two inch difference between row tops and valleys. This was much less than the difference produced by the Buffalo no-till cultivator the previous year; however, it still resulted in streaks of winterkill. The winter wheat was not interseeded with spring wheat, and yielded close to neighboring winter wheat stands. The reduced stand resulted in a flush of broadleaf weeds, which were controlled by 1pt/acre of Buctril sprayed broadcast on May 21. The red clover grew to within 2-4 inches of the winter wheat by harvest time. The wheat was cut as high as possible at harvest to avoid the clover, and the clover and straw was later harvested as haylage for the beef herd. (It would not have been possible to dry the lush clover growth enough to allow baling for straw, and the clover greatly outweighed the straw.)

To eliminate the wheat's streaked winterkill in 1994, the wide rowed soybeans were harvested and the plots lightly tilled with the soil finisher before the wheat was planted with the John Deere no-till drill. Only one day separated the harvest of the narrow row drilled soybeans (R2), a 2.7 maturity rating, and the wide rowed soybeans (R3), a 2.4 maturity rating. The wide rowed soybeans were harvested on October 12, and the wheat was drilled on October 13. This is past the optimum

* Assistant Superintendent at Arlington Agricultural Research Station.

seeding date and a 2.4 maturity soybean is likely too long to include in a double cropping regime. Although the fall weather was dry, it was cool, and the wheat had very little growth by winter. This may be a cause of concern in spring 1994.

Canada thistles were a growing problem in the corn no-tilled into soybean stubble, and perennial weeds will continue to be a problem, especially as R2 becomes a complete no-till system. Patches of canada thistles were sprayed with Stinger herbicide using a backpack sprayer. Accent herbicide was also spot sprayed on three plots to kill wheat that was over seeded by air when seeding adjacent R3 plots in the fall of 1992.

Wet soil conditions and weed germination over a longer period of time required a third rotary hoeing on the R3 and R5 corn. Wet soil conditions resulted in poorer mechanical weed control, more compaction, and a reduction in corn plant stands. These treatments could have used a third cultivation in mid July, but the corn was too tall for a cultivation at that time. Although the weed control was poor in the mechanically controlled corn, the rowed soybeans had excellent mechanical weed control and actually out-yielded the drilled soybeans. It should however be noted that water stood in several of the 200 series plots, including 206 -- drilled soybeans. The combine operator reported that the lower half of this plot yielded substantially less than the rest of the plot or other soybean plots.

APPENDIX III. **Lakeland Agricultural Complex - 1993 WICST Agronomic Report**

Alan Wood*

Expectations of having a good year for our project in 1993 quickly diminished with the advent of a cool and wet spring. May and June temperatures were below normal, and the total precipitation for these two months was 10.4 inches. Like 1992, all of the crops were again planted within a six day time frame, from May 11th (oats/alfalfa) to May 17th (direct-seeded alfalfa). Planting delays, less than optimum seedbeds, ineffective mechanical weeding, and timings of post-emergence herbicides were some of the problems caused by the spring weather conditions.

I will detail each system later, but will describe the various systems in general by crops. The same corn variety was used in all the plots (Pioneer 3563). On corn plots that received starter, the fertilizer was increased from 100 lbs. to 180 lbs. of 4-10-10. The reason for this change was that with our cold wet soils, we anticipated that additional starter would benefit early corn growth. Attempting to control weeds mechanically was frustrating. Wet soils made rotary hoeing ineffective (some plots could not be hoed at the optimum time because of standing water in the plots) and delayed row-cultivation. Yields in general were less than average with a declining trend over the last four years. This year marked the first time that two different soybean varieties were used. In System 3, an earlier maturing variety was used to facilitate an earlier planting date on winter wheat. Winterkill in our established alfalfa plots was a severe problem this spring (50% or greater stand losses). We decided to no-till annual ryegrass and red clover into those plots in an attempt to provide adequate yield this year and to re-establish a legume for the nitrogen credits during the corn phase of the system.

SYSTEM 1: CONTINUOUS CORN

This system did not deviate from the proposed plan except that there was a high percentage of lambsquarter escapes. We need to check and verify if a triazine resistance problem is developing. Buctril herbicide was used as a rescue treatment to control the lambsquarter (1 pt/a.). This system has been using atrazine as part of its weed control plan. Discussions by the advisory committee had recommended that it be eliminated to conform more closely with the new Wisconsin Atrazine Rule. At the request of the Wisconsin Dept. of Agriculture, Trade and Consumer Protection, atrazine will be a component of the weed control plan for this system so that they can monitor the long term effect on the groundwater.

SYSTEM 2: CORN/SOYBEANS

This system was one of the easier rotations to manage given our weather conditions. No-till in 1993 worked regardless of how that operation was performed. One deviation from the proposed plan was switching the grass herbicide from Poast Plus to Assure II. The reason was a cheaper cost per acre with the same performance results. One observation about the herbicide program was the injury and set back to the soybean plants. The problem seems to come from the broadleaf herbicides (Classic and Pinnacle). I've seen this problem in previous years but not to the extent of set back to the growth of the soybean plant this year (it also appeared in LAC's production fields).

SYSTEM 3: CORN/SOYBEANS/WHEAT/RED CLOVER

This system can be summed up in one word - frustrations. I don't know where to begin talking about this rotation, so I will start with the corn phase and discuss it's problems. In the past, we have removed the red clover stand by undercutting it in the spring with a chisel plow equipped with sweeps. In 1993 we didn't deviate from that plan and again undercut in the spring. There have

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* Superintendent at the Lakeland Agricultural Complex.

been many discussions about whether this has affected the corn performance. For the 1994 plan, the red clover will be undercut in the fall of 1993. So stay tuned for further developments in this regard. The weed control was handled with two rotary hoeing and **three** cultivations (except plot no. 306 which was too wet). The third cultivation was a deviation from the proposed plan. One strategy to assist in weed control is to perform the first secondary tillage about 10 to 14 days before planting. This would allow a flush of weed to germinate and the second tillage would then eliminate those weeds. The wet weather didn't allow us to perform this strategy as per our plan. Why are the corn yields so low? Everybody has lots of opinions but not many reasons based on facts. Is the nitrogen from the red clover being released too late for the corn to utilize it when it needs it? Was the preparation of the seedbed inadequate because of wet soil conditions? Did a higher percentage of stand reduction occur because of wet soil conditions during rotary hoeing? Was the weed competition great enough to affect yield? Would starter fertilizer have been a benefit this year in the cold wet soils? There are lots of questions and not very many answers. The soybean phase didn't fare much better. Kaltenberg 241 was the earlier maturing variety used to assist in moving the wheat planting date earlier. Again, the weed control proposal included two rotary hoeing and two cultivations. The wet weather forced us to deviate from that plan and use three rotary hoeing and three cultivations (three cultivations on plot 406 only, others were too wet). I believe that the intense weed competition was a major factor in the reduced soybean yield. Farmers would have used a rescue treatment to help correct this problem unless they were trying to become organically certified. One observation I made was that the soybean growth was retarded until dryer conditions prevailed. At times there was water standing between the rows and soybeans do not like to have wet feet. This brings us to the third phase of this rotation, the winter wheat/red clover crop. The low yields in this phase had been a major concern since the initial wheat crop. What are some of the perceived problems? Cultivation of the rowed soybeans leaves ridges and valleys in the fields. The soybean row is on a ridge and the valley is between the rows of soybeans. Initial germination of the wheat seed in the fall is good in the valleys and average on the ridge tops. Due to icing in the late winter and standing water in the early spring, the stand density is either reduced or eliminated in the valleys which leaves a poor population of wheat for the remainder of the field. A reduced stand density and less than adequate tillering of the wheat is the main reason for substandard yields over the past three years. Another problem with a reduced stand of wheat was the competitive growth of the red clover. At wheat harvest, the red clover was about 6 to 8 inches shorter than the wheat. This forced us to harvest the wheat heads only and then it was necessary to harvest the remaining red clover and wheat stalks as a forage. The normal plan it to bale the wheat straw and use it for bedding purposes. The tremendous red clover stand should provide adequate nitrogen needs for the 1994 corn crop. The red clover was frost seeded on April 7th using an ATV with a Herd spinner seeder (20 lbs/a.). The red clover was killed in the fall using a John Deere 550 Mulchmaster with 24" sweeps instead of the chisel plow with sweeps (chisel plow was not available at the time). I only hope that we have learned enough about this system over the last four years that we can start to fine tune our production methodology for the future.

SYSTEM 4: CORN/GREEN GOLD ALFALFA

The corn phase had no problems except for a mistake in nitrogen application. The proposed input sheet indicated that 140 lbs of actual nitrogen was to be applied. When actually no additional nitrogen was needed. Nitrogen overloading occurred in this phase because of the N credit from the alfalfa legume, the nitrogen obtained from applying 20 tons/acre of dairy cattle manure plus the additional nitrogen from the commercial source. While it was a mistake, the economics should factor it whether there was a response to the additional nitrogen or not. The corn in this system had the highest yield, but it was not significantly higher considering the amount to nitrogen available to it. The major problem in 1993 was the winter kill of the alfalfa stands. While most farmers would have rotated the fields into corn, we decided to rescue the stands using annual ryegrass and red clover. The idea of the annual ryegrass was to provide forage yield in the initial year. The red clover was also to provide some additional yield and also to re-establish the legume for the nitrogen credit for the corn crop that will be following. On May 8th, the annual ryegrass and red clover were no-tilled into the fields. Based on only one year of information, this proved to be a very successful operation. Average yields for Est. Alfalfa I were 2.9 tons/a and for Est. Alfalfa II were 2.6 tons/a. The annual ryegrass provided early forage yields and the red clover provided late season yield increases. Would this rescue treatment work every year? That's a question that I would not have a definite answer for at this time based on only one year of information. The real answers will come next year when the Est. Alfalfa I plots are harvested and the yield recorded. Because of the wet late spring and the re-seeding, only three harvesting were taken from this system instead of the proposed four cuttings. The final phase of this rotation is the direct seeded alfalfa crop. While the initial germination of the alfalfa seed was good, root diseases destroyed many of the young seedlings. Only one harvest cutting was recorded and the yield was very low. After harvest, the areas of the field with reduced stand density were re-seeded with a no-till drill.

SYSTEM 5: CORN/OATS/ALFALFA

Unlike system 3, where we attempted to cultivate three times, the weed control plan for corn was followed as proposed. While system 3 and system 5 are somewhat similar, there is a different weed spectrum present. Is this the difference between the red clover and alfalfa or is it for other additional reasons? Some of the same questions that surfaced in System 3 could be asked here. Was the seedbed prepared as good as it should be? Did the alfalfa residue release its nitrogen at the correct time? Why was the yield as low as it was? I don't have the answers to these questions at this time. For the third year in a row, the oats was seeded about 20 to 30 days later than the optimum planting date. Both the oats and alfalfa were seeded with a John Deere 750 no-till drill into a tilled seedbed. The planting depth was ½", which was adequate for alfalfa but too shallow for oats. This resulted in a reduced stand density and variations in plant heights. For this reason the crop was harvested as oatlage instead of grain as per the proposed plan. The same winter kill problem occurred in the Est. Alfalfa I fields as in system 4. The rescue treatment also was the same as in System 4, annual ryegrass and red clover no-till drilled into the existing crop. The results were the same as System 4 throughout the year. Only three harvest cuttings were removed from this system due mainly to the winterkill problems.

SYSTEM 6: ROTATIONAL GRAZING

After the successful year of grazing heifers in 1992, I was very enthusiastic about 1993. Disappointment soon replaced enthusiasm when the heifers were weighted for the first time. The rate of gain was less than 1 lb/day/animal. A far cry from the goal of 1.8 lbs./day/animal. While there was adequate amounts of forage, the quality was of some concern. Also, this year the plots were stocked with three heifers each instead of two. The heifers were introduced to the plots on May 8 and one heifer from each plot was removed on July 23 because of the poor rate of gain and lack of forage. Additional grain and hay were fed to all the heifers at various times throughout the summer. The heifers were removed from the plots on October 7 with a full season 1.65 lb/day/animal rate of gain. This was better than the early indications but still slightly below the goal of 1.8 lb/day/animal and well short of 1992's 2.27 lbs./day/animal. Let's hope 1994 is more of a repeat of 1992. The pastures were frost seeded with red clover at 20 lb/acre on April 7 . Initial observations were that this was a successful operation. Next year will give us a better answer as to the success of the frost seeding.

In general, 1993 was a difficult year and now that it's over, its time to concentrate on making the adjustments necessary for the 1994 WICST cropping adventures.

APPENDIX IV. **Fall Nitrate Monitoring Under Different Cropping Systems**

T. K. Iragavarapu*, T. A. Mulder**, J.O. Baldock**, and J.L. Posner**

The amount of inorganic N remaining in the soil profile following crop harvest is an important factor that reflects the nitrate leaching potential of a particular field situation (Magdoff, 1991). That is, the accumulated nitrate-nitrogen (NO3-N) is often, but not always, subject to significant leaching losses in late fall and early spring. There are two major reasons that NO3-N would be left in the soil after crop uptake has ceased: a) N uptake was less than expected (due to poor soil structure, drought, pest damage, etc.), and b) over fertilization (due to overestimation of crop yield, failure to credit the N in manure or previous legume crops, greater mineralization than anticipated, etc.). Minimizing the amount of NO3-N left in the fall not only reduces the potential for losses to ground and surface water, but it may also increase farm income by avoiding over fertilization. Therefore, monitoring the soil NO3-N levels under six cropping systems has been an important activity of the WICST.

In 1990, 1991, and 1992 soil nitrate samples were taken in 1-foot increments to a depth of three feet with a 1.5" diameter probe. Five cores were taken per plot and bulked by depth. A more complete discussion of this monitoring activity is found in the Second Annual Technical Report (pages 52-59). In 1993 two changes were made to improve the soil NO3-N data and reduce the effort required to obtain it. First, the number of cores per plot was increased to six. That change was made after the NO3-N levels in six individual cores per plot from a preliminary sampling of Treatments 1, 8, and 14 in the summer of 1993 were analyzed to determine the variance components for experimental error and sampling error. Second, on eight of the treatments (2, 4, 6, 8, 9, 10, 12, and 13), 2-foot cores were taken because the third foot presented the greatest problem in sampling. That reduction in effort was justified by the work of Ehrhardt and Bundy (1995), in which they found that the third foot NO3-N levels could be predicted by the levels in the second foot. To provide a check on that finding, the other six treatments were sampled to the full 3-foot depth In all years, sampling took place after soil temperatures dropped to 50 F, which ensured that changes in NO3-N due to biological activity were minimal.

The treatment means are given by site and year in the accompanying table. In 1992 and 1993 the fall soil NO3-N levels under most of the treatments were only slightly above the 50 lb NO3-N/A, which is considered as the background level (Bundy et al., 1992). Thus, most of the rotation phases have not resulted in NO3-N accumulations that would create a large leaching potential. The possible exceptions were the corn phases of the systems receiving commercial nitrogen fertilizer or dairy manure.

The second foot NO3-N level was a good estimator of the third foot level. A prediction equation for each site was developed using the 1990-1992 data:

ARS Data equation: $Y = 2.81 + 0.754x$, $n = 103$ and $r^2 = 0.70$
LAC Data equation: $Y = 0.66 + 0.829x$, $n = 106$ and $r^2 = 0.77$
where Y is 3rd foot NO3-N content and x is the 2nd foot NO3-N content (both in lbs/a).

Two outliers for the Lakeland data and five for the Arlington data were omitted in developing those equations. The similarity of the x coefficient in those site-specific equations to the statewide equation for all crops (0.709) reported by Ehrhardt and Bundy (1995) is reassuring. The difference in Y-intercepts between sites and the statewide model (9.1) can probably be attributed to soil and

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rainfall differences. For Arlington in 1993 the agreement between the 3rd-foot NO3-N levels predicted by those equations and the measured levels was poor. Below 20 lbs/a in the 3rd foot, the equations tended to overestimate NO3-N, but above 20 lbs/a the equations underestimated it. However, the errors were mostly less than 10 lbs/a and all were less than 20 lbs/a. At Lakeland, the trend between the predicted and actual NO3-N in the third foot was much closer to the theoretical 1:1 line. On the other hand, the magnitude of the errors was the same as at Arlington. There was an indication at both sites that developing a separate prediction equation for fertilized and manure plots would be beneficial.

Similar to the P and K data discussed in Appendix V, these soil NO3-N data can be analyzed on a field basis, a whole-farm basis, or a cropping system cycle basis. The statistical analysis for each of these approaches is slightly different and rather complicated. Until now there has not been enough data from different years and phases to undertake those more rigorous analyses. However, beginning with the 1994 data there should be adequate information to make those analyses worthwhile. Also, continued work on the sampling scheme and relationship between the 3rd foot and the rest of the profile should prove fruitful in terms of obtaining better data and reducing the sampling difficulties.

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APPENDIX IV. **Fall Nitrate in the top 3 ft of the soil profile at the Arlington Research Station (ARS) and Lakeland Agricultural Complex (LAC) WICST sites: 1990-1993.**[1/]

Rotation/Crop	ARS				LAC			
	1990	1991	1992	1993	1990	1991	1992	1993
	(lb/A)							
Corn:								
R1 Cont. Corn	87.0	47.5	97.0	102.4	197.5	132.3	86.0	134.3
R2 Corn after Soybeans	-	41.0	104.5	104.5	-	124.8	78.0	56.8
R3 Corn after Red Clover	-	-	66.5	82.8*	-	-	61.5	58.9*
R4 Corn after Alfalfa	-	-	-	142.3	-	-	-	121.8
R5 Corn after Alfalfa	-	-	100.8	117.9*	-	-	80.5	79.6*
Soybean:								
R2 Narrow-row Soybeans	78.0	41.5	74.0	99.8*	54.5	75.8	86.0	86.2*
R3 Wide-row Soybeans	74.5	24.5	65.5	89.2	48.8	33.8	62.5	86.0
Wheat:								
R3 Wheat/Red Clover	-	25.5	48.0	64.9*	-	49.3	44.5	56.1*
Alfalfa:								
R4 DS Alfalfa	46.3	31.5	60.5	79.5*	33.5	66.5	41.0	78.3*
R4 Alfalfa Hay I	-	26.5	49.0	54.9*	-	70.8	53.5	71.4*
R4 Alfalfa Hay II	-	-	59.8	68.9*	-	-	63.0	59.6*
R5 Alfalfa with Oats	-	-	-	102.5	-	-	-	53.4
R5 Alfalfa	-	-	-	83.9*	-	-	-	78.2*
Pasture:								
R6	-	-	-	90.7	-	-	-	65.8

[1/] Staggered start - soil nitrates not tested until after first season in the rotation.

* Only top 2 feet tested - 3rd foot estimated using the following regression equations that were formulated using available fall 2nd and 3rd foot nitrate data from the two sites:

$Y = 2.81 + 0.754x$ (ARS data), $n=103$ and $r^2=0.70$;

$Y = 0.66 + 0.8296x$ (LAC data), $n=106$ and $r^2=0.77$;

where Y is lb/A 3rd foot nitrate content and x is lb/A 2nd foot nitrate content.

APPENDIX IV. **WICST Nitrogen Balance 1990-1993***

Rotation	Crop	Arlington Ag. Res. Station 1990	1991	1992	1993	Lakeland Ag Complex 1990	1991	1992	1993
	90-91-92-93	lb/a							
R1	C-C-C-C	-56	-1	+43	+98	+39	+4	+63	+160
R2	Sb-C-Sb-C	-151	-46	-50	+54	-134	+6	-77	+246
R2	★-Sb-C-Sb		-188	+25	-174		-184	+31	-160
R3	Sb-W/c-C-Sb	-146	-80	-74	-173	-138	-36	-44	-105
R3	★-Sb-W/c-C		-157	-47	-48		-161	-24	-11
R3	★-★-Sb-W/c			-61	-91			-19	-107
R4	A-A-A-C	-1	-236	-234	+127	+248	-209	-234	+233
R4	★-A-A-A		-44	-190	-197		+235	-249	-156
R4	★-★-A-A			-51	-183			+238	-165
R4	★-★-★-A				+3				+248
R5	O/a-A-C-O/a	-41	-331	+78	-68	+168	-193	-64	+128
R5	★-O/a-A-C		+70	-309	+63		+120	-237	+157
R5	★-★-O/a-A			+6	-282			+170	-194
R6 [1/]	P-P-P-P	-130	-141	-45	+0	+117	-56	-23	+47

* Nitrogen applied (fertilizer or manure) minus crop removal.

[1/] Removal includes nitrogen in harvested crop and/or in live weight gain of animals.

APPENDIX V. **WICST P and K Fertility Budgets by Rotation (1989-1993)**

T. K. Iragavarapu*, T. A. Mulder**, J.O. Baldock**, and J.L. Posner**

During the past 30 years, high-input systems have resulted in a build-up of soil fertility on many conventional farms. On the other hand, most scientists believe that low- or zero-input systems will mine the soil and ultimately reach an equilibrium at an uneconomically low yield level. The cropping systems in the WICST includes BMP inputs and the zero-input extreme, hence it was decided to monitor soil fertility levels with routine soil testing.

In 1990, 1991, and 1992 five 1.5" diameter soil cores were taken per plot and bulked. Sampling was done at 0-6", 6-12", 12-24" and 24-36" every fall. A more complete description of this monitoring activity is presented in the Second Technical Report (pg 60-64). Starting in 1993, it was decided to sample all four depths only once in each cycle (in the fall of the corn phase), but to continue sampling the 0-6" depth every year. It was also decided that six cores would be taken as three pairs of cores with the cores in each pair taken 15" apart. That would help prevent getting several cores from recent fertilize bands.

Tables of the treatment-by-year means for soil test levels and net plant nutrient inputs are included at the end of this appendix. At both sites, in all rotations, phosphorous soil test levels (Bray-1 extract) have dropped since the initiation of the experiment. At both sites however, available P levels (ARS- 89 ppm; LAC- 62 ppm) are well above the optimum (20 ppm). Because of the high fertility levels, BMP's have dictated that P and K additions should be minimized. Consequently, additions in the cash grain rotations have been less than removal so it is not surprising that soil test levels are dropping toward the recommended levels. In the dairy rotations however, the additions of manure result in P inputs that are somewhat greater than off take. Nevertheless, the soil test levels are dropping in those rotations, too; which may be because the nutrient inputs are in an organic form which may not be as easily extracted by the soil test procedures.

As with phosphorous, the initial potassium levels at both sites (ARS- 237 ppm; LAC- 187 ppm) were well above the optimum (90 ppm). Again, the soil test levels are dropping in almost all the rotations. The major exceptions to this observation are the continuous corn at Arlington, and the R5 rotation at Lakeland. In the case of the former it has been suggested that the high K content of the corn stover results in phyto-cycling of potassium to the surface in continuous corn (personal communication E. Schulte). In the latter, poor forage yields at Lakeland can explain why the manure additions have been more than enough to maintain and build soil K levels.

In summary, the treatment mean soil P and K levels are beginning to show some interesting trends and differences. However, extreme caution should be exercised in using those data until they are subjected to rigorous statistical analyses.

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APPENDIX Va. WICST Soil Test Results (0-6 in) 1989-1993 - Arlington Agricultural Research Station

Rotation	Crop	Phosphorous					Potassium				
		1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
	89-90-91-92-93	ppm									
R1	★-C-C-C-C	105	-	-	93	84	257	-	-	219	295
R2	★-Sb-C-Sb-C	98	-	-	79	65	199	-	-	239	229
R2	★-★-Sb-C-Sb		88	-	89	78		283	-	198	264
R3	★-Sb-W/c-C-Sb	105	-	-	69	64	236	-	-	189	251
R3	★-★-Sb-W/c-C		69	-	-	57		200	-	-	226
R3	★-★-★-Sb-W/c			57	-	53			195	-	201
R4	★-A-A-A-C	115	-	-	94	85	277	-	-	175	216
R4	★-★-A-A-A		93	-	105	81		256	-	203	170
R4	★-★-★-A-A			66	-	62			214	-	170
R4	★-★-★-★-A				77	71				189	224
R5	★-O/a-A-C-O/a	110	-	-	103	88	250	-	-	198	236
R5	★-★-O/a-A-C		70	-	72	67		211	-	181	210
R5	★-★-★-O/a-A			84	-	73			293	-	211
R6	★-P-P-P-P	114	-	-	-	82	266	-	-	-	186

* samples collected after crop harvest
** original overall fertility average (top 6 inches of soil profile): P-89 ppm, K-238 ppm.
★ = filler corn (grown prior to initiation of each rotation)

APPENDIX Vb. WICST Soil Test Results (0-6 in) 1989-1993 - Lakeland Agricultural Complex

Rotation	Crop	Phosphorous 1989	1990	1991	1992	1993	Potassium 1989	1990	1991	1992	1993
	89-90-91-92-93	ppm									
R1	★-C-C-C-C	66	-	-	58	52	196	-	-	205	185
R2	★-Sb-C-Sb-C	59	-	-	52	47	178	-	-	186	158
R2	★-★-Sb-C-Sb		65	-	53	43		193	-	204	196
R3	★-Sb-W/c-C-Sb	64	-	-	46	39	195	-	-	173	181
R3	★-★-Sb-W/c-C		54	-	-	36		153	-	-	173
R3	★-★-★-Sb-W/c			49	-	39			183	-	179
R4	★-A-A-A-C	76	-	-	57	51	148	-	-	121	145
R4	★-★-A-A-A		59	-	52	52		179	-	171	165
R4	★-★-★-A-A			37	-	36			149	-	181
R4	★-★-★-★-A				59	62				181	203
R5	★-O/a-A-C-O/a	53	-	-	41	52	163	-	-	161	205
R5	★-★-O/a-A-C		68	-	55	48		213	-	159	181
R5	★-★-★-O/a-A			54	-	46			171	-	200
R6	★-P-P-P-P	63	-	-	-	41	181	-	-	-	166

* samples collected after crop harvest

** original overall fertility average (top 6 inches of soil profile): P-59 ppm, K-182 ppm.

★ = filler corn (grown prior to initiation of each rotation)

APPENDIX Vc. WICST Nutrient Balance 1990-1993 - Arlington Agricultural Research Station

Rotation	Crop	Phosphorous				Potassium			
		1990	1991	1992	1993	1990	1991	1992	1993
	90-91-92-93	lb/a							
R1	C-C-C-C	-15	-14	-11	-4	-8	-8	-6	-4
R2	Sb-C-Sb-C	-21	-18	-11	-6	-62	-12	-33	-7
R2	★-Sb-C-Sb		-23	-9	-20		-67	-5	-69
R3	Sb-W/c-C-Sb	-21	-16	-15	-25	-56	-33	-19	-61
R3	★-Sb-W/c-C		-18	-10	-12		-57	-17	-19
R3	★-★-Sb-W/c			-14	-16			-42	-81
R4	A-A-A-C	+34	-31	-26	+55	-94	-296	-212	+253
R4	★-A-A-A		+39	-23	-23		-125	-212	-206
R4	★-★-A-A			+41	-26			-13	-190
R4	★-★-★-A				+45				+74
R5	O/a-A-C-O/a	+31	-32	+32	+52	-122	-316	+178	+73
R5	★-O/a-A-C		+27	-30	+52		+5	-261	+146
R5	★-★-O/a-A			+30	-23			-34	-258
R6 [1/]	P-P-P-P	+13	+5	+16	+2	-213	-184	-51	-1

* Nutrient additions by fertilizer or manure and removal by crop harvest.

[1/] Nutrient additions from manure, fertilizer, fed hay, and fed grain and removal from live weight gain of animals and harvested hay

APPENDIX Vd. WICST Nutrient Balance 1990-1993 - Lakeland Agricultural Complex

Rotation	Crop	Phosphorous 1990	1991	1992	1993	Potassium 1990	1991	1992	1993
	90-91-92-93	lb/a							
R1	C-C-C-C	-14	-16	-17	-5	-13	-14	-20	-6
R2	Sb-C-Sb-C	-15	-11	-17	-6	-47	-0	-52	-6
R2	★-Sb-C-Sb		-20	-20	-17		-65	-23	-58
R3	Sb-W/c-C-Sb	-15	-8	-12	-10	-48	-16	-18	-35
R3	★-Sb-W/c-C		-17	-6	-11		-56	-6	-18
R3	★-★-Sb-W/c			-19	-16			-59	-91
R4	A-A-A-C	+99	-21	-25	-8	+279	-214	-206	-9
R4	★-A-A-A		+122	-25	-19		+257	-227	-190
R4	★-★-A-A			+20	-20			+414	-176
R4	★-★-★-A				+87				+295
R5	O/a-A-C-O/a	+64	-20	+28	+146	+183	-172	+409	+191
R5	★-O/a-A-C		+53	-23	+145		+92	-207	+278
R5	★-★-O/a-A			+36	-25			+283	-230
R6 [1/]	P-P-P-P	+41	+16	-6	+1	+133	-97	-1	+30

* Nutrient additions by fertilizer or manure and removal by crop harvest.

[1/] Nutrient additions from manure, fertilizer, fed hay, and fed grain and removal from live weight gain of animals and harvested hay

APPENDIX VI. **Effect of Cropping System on Nitrate + Nitrite-N Concentration in the Groundwater at the Lakeland Agricultural Complex**

T. K. Iragavarapu*, T. A. Mulder**, J.O. Baldock**, and J.L. Posner**

Much of the work on the effect of cropping systems on groundwater quality has been conducted in high risk situations such as on very sandy soils, with significant supplemental irrigation, or where excessively large nitrogen additions have been applied. At the Lakeland site, on a typical midwestern silt-loam soil, the groundwater is usually within 5 to 10 feet of the surface. In the early spring of 1991, PVC wells (1.5 in.i.d.) were installed to a 12-foot depth. The lower 4 feet were perforated. Sampling of the wells has been conducted since that time in the fall of each cropping season. A complete description of this monitoring activity is described in the Second Annual Technical Report (pages 65-75).

As can be seen in the appendix table, the cash grain rotations had nitrate + nitrite-N levels somewhat higher than the forage based rotations in Nov. 1993, and that the high input continuous corn rotation is associated with the highest levels. All the cropping systems appear to be trending toward lower nitrate levels since 1991 with the Corn-Soybean-Wheat(red clover) and Rotation Grazing systems showing the sharpest decline. Although the numbers are still well above the two check wells (last two rows), all the samples in 1993 were below the safe limit of 45ppm (nitrate + nitrite N).

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** Project manager, interim Project Coordinator and Project statistician, and Project Coordinator respectively

APPENDIX VIa. **Nitrate + Nitrite-N Concentrations in Ground Water at LAC - 1990-1993**[1/]

Field ID#	Treatment #	water collection dates 5/20/91	12/10/91	4/23/92	12/9/92	11/23/93
		ppm				
101	1	80.8	41.5	40.2	39.7	29.2
210	1	52.8	48.5	46.1	44.2	42.0
303	1	34.9	21.3	38.5	36.4	28.5
Mean		56.2	37.1	41.6	40.3	33.2
Crop	continuous Corn	C		C		C
108	2	70.8	60.5	55.9	47.8	45.6
203	2	11.4	14.0	26.0	20.0	18.7
304	2	12.8	20.1	28.1	20.1	16.4
Mean		31.7	31.5	36.7	29.3	26.9
Crop	C-Sb	Sb		C		Sb
111	6	60.8	43.8	9.1	18.4	14.5
208	6	37.3	28.6	14.9	38.4	21.3
306	6	28.8	42.3	9.4	23.8	23.1
Mean		42.3	38.2	11.3	26.9	19.6
Crop	Sb-W/rc-C	Sb		W/rc		C
102	8	38.7	15.1	12.5	4.84	2.94
209	8	48.8	6.8	14.9	14.4	20.1
305	8	34.8	10.3	8.5	5.73	9.00
Mean		40.8	10.7	12.0	8.3	10.7
Crop	C-A-A-A	A		A		A
105	12	16.5	15.4	21.8	10.8	10.4
207	12	69.6	49.7	3.9	38.7	26.1
309	12	11.9	7.3	56.1	8.34	13.3
Mean		32.7	24.1	27.3	19.3	16.6
Crop	O/A-A-C	O/A		A		C
104	14	24.7	21.3	2.8	21.4	18.4
213	14	--	2.2	29.6	2.84	3.25
314	14	--	63.2	--	30.0	16.1
Mean		24.7	28.9	16.2	18.1	12.6
Crop	Rotational grazing [2/]			RG		RG
1s[1]	-	--	31.1	2.8	2.07	2.32
1d[2]	-	--	6.9	29.6	10.6	ND

[1/] Wells 18 feet deep, normal ground water depth < 10 feet below surface.
[2/] Red Clover/Grass removed as hay 1991, grazed 1992 & 1993

[1] Check well #1 - 13 feet deep
[2] Check well #2 - 28 feet deep
ND = no detection

APPENDIX VII. **Energy Use and Output/Input Ratios for the Six WICST Cropping Systems 1990-1993.** [1/]

Rotation	Crop	Crops or completed rotations	Energy input/yr ARS	Energy input/yr LAC	Output/input avg. ARS	Output/input avg. LAC
		-- # --	-- Mcal/A --		- ratio -	
1	Corn	4	2713	2292	5.2	4.2
2	Soybean	4	457	495	15.6	13.8
	Corn	3	2611	2129	5.7	5.5
	System average[2/]	3	1547	1314	7.1	7.1
3	Soybean/Wheat	4	460	487	12.9	12.0
	Wheat/Red Clover	3	777	815	9.7	6.8
	Corn	2	2113	1430	4.2	4.9
	System average	2	1163	931	6.0	6.5
4	Direct Seeded Alfalfa	4	1812	1491	8.5	1.3
	Alafalfa I	3	718	719	23.3	18.6
	Alfalfa II	2	870	775	16.0	15.3
	Corn	1	1985	1358	7.9	7.9
	System average	1	1380	1172	10.0	7.2
5	Oats/Alflafa	4	1020	979	11.0	6.4
	Alfalfa I	3	664	790	30.3	16.8
	Corn	2	2021	1118	3.6	5.2
	System average	1	1198	959	9.8	8.9
6	Rotational Grazing[3/]	4	651	389	21.5	28.8

[1/] See Appendix II in the 1992 Annual Report (pp 118-121) for information on calculation of the energy values.
[1/]Averages calculated using data from years when all the crops of a particular system were grown.
[2/] Forage harvested mechanically until animals began grazing in 1992 at LAC and 1993 at ARS; with grazing animals, energy output calculated using weight gain.

APPENDIX VIII.A. **ARLINGTON AGRICULTURAL RESEARCH STATION WICST INPUT/OUTPUT DATA - 1993**

Corn Treatments

Crop-93	Cont. Corn	Corn	Corn	Corn	Corn
Prev Crop	Corn	Soybean	Wheat/RC	Alfalfa II	Alfalfa I
Rotation	R1	R2	R3	R4	R5
Treatment	1	3	6	7	12
Plot #'s	109,204, 306,412	101,214, 303,401	102,212, 313,407	111,209, 305,409	103,213 314,410
Primary Tillage	Chisel Plow 11/30/92	No-till	Chisel Plow Sweeps 5/12/93	Chisel Plow Sweeps 12/1/92	Chisel Plow Sweeps 12/1/92
Secondary Tillage	Disk 4/30/93 Soil Finisher 5/1/93	None	Disk 2X 5/12/93	Disk 4/30/93 Soil Finisher 5/1/93	Disk 4/30/93 Soil Finisher 5/12/93
Planted	5/1/93	5/1/93	5/13	5/1	5/13
Variety	Pioneer 3417	Pioneer 3417	Pioneer 3563	Pioneer 3417	Pioneer 3563
Rate	32,500	32,500	32,500	32,500	32,500
Fertilizer					
Starter	100 lb 6-24-24	100 lb 6-24-24	None	100 lb 6-24-24	None
Nitrogen	160 lb N/a as 82-0-0 4/30/93	120 lb N/a as 82-0-0 6/30/93	None	None	None
Manure	None	None	None	20 Ton/a 11/23/92	15 Ton/a 11/30/92
Pesticides	pre 5/7/93 Dual 2 pt/a postemerge Buctril 1 pt/a 6/10/93 Counter 15G 9 lb/a with planter	pre 5/7/93 Dual 2 pt/a postemerge accent 2/3 oz/a 5/21/93 [1] stinger .5 pt/a 5/27/93 [2] Buctril 1 pt/a 6/10/93	None	pre 5/7/93 Dual 2 pt/a postemerge Buctril 1 pt/a 6/10/93	None
Rotary Hoe	None	None	#1 5/21/93 #2 5/28/93 #3 6/7/93	None	#1 5/21/93 #2 5/28/93 #3 6/7/93
Cult.	S-tine 7/5/93	S-tine 7/5/93	S-tine 6/18/93 7/5/93	S-tine 7/5/93	S-tine 6/18/93 7/5/93
Harvest	11/1/93	11/1/93	11/1/93	11/1/93	11/1/93
Yield	124 bu/a	130 bu/a	87 bu/a	165 bu/a	119 bu/a
Fall Practices	Chisel Plow 11/9/93	None	Chisel Plow 11/9/93	20 T/a manure 11/7/93 Chisel Plow 11/9/93	15 T/a manure 11/7/93 Chisel Plow 11/9/93
Crop-94	Corn	NR Soybean	WR Soybean	D.S. Alfalfa	Oats/Alfalfa

[1] Applied to plots 101, 214, 401 to kill volunteer aerial seeded wheat
[2] Spot sprayed on thistle patches

APPENDIX VIII.B. **ARLINGTON AGRICULTURAL RESEARCH STATION WICST INPUT/OUTPUT DATA - 1993**

Soybean and Wheat Treatments

Crop-93	NR Soybean	WR Soybean/ Wheat	Wheat/ Red Clover
Prev. Crop	Corn	Corn	Soybean/Wheat
Rotation	R2	R3	R3
Treatment	2	5	4
Plot #'s	108,206, 310,408	106,202, 307,411	104,201, 301,402
Primary Tillage	Chisel Plow 11/30/92	Chisel Plow 11/30/92	None
Secondary Tillage	Disk 4/30/93 Soil Finisher 5/12/93	Disk 4/30/93 Soil Finisher 5/12/93	None
Planting Date	5/13/93	5/13/93	9/18/92 Wheat 4/2/93 Rd Clov [1/]
Variety	Pioneer 9372	Kaltenberg 241	Arlington RC
Rate	235,000 seeds/a	156,000 seeds/a	180 lb/a Wheat 20 lb/a Rd Clov.
Fertilizer	None	None	None
Pesticides	postemerge .25 oz/a Classic .25 oz/a Pinnacle 6/16/93 1.5 pt/a Poast 6/21/93	None	postemerge 5/21/93 Buctril 1 pt/a [2/]
Rotary Hoe	None	#1 5/21/93 #2 6/5/93	None
Cultivation	None	S-tine 6/18/93 7/5/93 7/16/93	None
Harvest	10/13/93	10/12/93	7/28/93
Yield	53 bu/a	53 bu/a	29 bu/a wheat 1.43 T/a straw
Fall Practices	None	Soil Finisher 10/12/93 No-till drill Merrimac w.wheat 150 lb/a 10/13/93	Chisel plow (sweeps) 11/8/93
Crop-94	Corn	Wheat/Red Clover	Corn

[1/] Seeded with hand operated spreader
[2/] Applied to control common lambsquarter between rows of wheat

APPENDIX VIII.C. **ARLINGTON AGRICULTURAL RESEARCH STATION WICST INPUT/OUTPUT DATA - 1993**

Forage Treatments

Crop-93	D. Seeded Alfalfa	Estab. Alfalfa I	Estab. Alfalfa II	Oats/ Alfalfa	Estab. Alfalfa I	Pasture
Prev. Crop	Filler Corn	D.S. Alf.	Alfalfa I	Corn	Oats/Alf.	Pasture
Rotation	R4	R4	R4	R5	R5	R6
Treatment	10	9	8	11	13	14
Plot #'s	107,205 309,404	105,203 308,406	113,210, 311,414	110, 208 304, 413	114,211, 312,403	112,207 302,405
Primary Tillage	Chisel Plow 11/30/92			Chisel Plow 11/30/92		
Secondary Tillage	Disk 4/30/93 Soil Finisher 5/1/93			Disk 4/30/93 Soil Finisher 5/1/93		
Planting Date	5/1/93	4/7/92 4/28/93 [1/]	4/8/91 4/28/93 [1/]	5/1/93	4/7/92 4/28/93 [1/]	4/23/90 4/30/92 O gr/Br/Tim 7/31/92 O gr 4/9/93 [2/]
Variety	Magnum III	Magnum III	Magnum III	Prairie-oats Magnum III-alf.	Magnum III	Timothy-Toro Brome-Badger Arl Rd Clov[2/]
Planting Rate	15 lb/a			64 lb/a oats 15 lb/a alfalfa		6 lb/a O gr 12 lb/a Br 6 lb/a Tim 4.5 lb/a O gr 12 lb/a RC[2/]
Fertilizer		None	None		None	
Manure	20 ton/a 11/23/92			15 ton/a 11/30/92		grazing
Pesticides	Eptam 2 qt/a ppi 5/1/93	None	2,4-D 1 pt/a Banvel .5 pt/a 10/6/93	None	None	None
Harvest	7/16/93 haylage 9/2/93 haylage	6/11/93 haylage 7/13/93 haylage 9/2/93 haylage	6/11/93 haylage 7/13/93 haylage 9/2/93 haylage	8/11/93 oats 8/13/93 straw	6/11/93 haylage 7/14/93 haylage 9/2/93 haylage	begin grazing 5/17/93 bale excess 6/11/93
Yield	3.27 tDM/a	3.70 tDM/a	3.25 tDM/a	62 bu/a 1.52 tDM/a	4.65 tDM/a	0.4 tDM/a hay 482 lb gain/a
Fall Practices	None	None	20 T/a manure 11/7/93	None	15 T/a manure 11/7/93	None
Crop-94	Alfalfa I	Alflafa II	Corn	Alafalfa I	Corn	Pasture

[1/] No-till drill
T9 105 - whole plot 5 lb/a perennial rye, 203, 308, 406 - whole plots 5 lb/a perennial rye + 8 lb/a Magnum alfalfa
T8 whole plots 5 lb/a perennial rye + 6 lb/a Alington red clover
T13 114 - whole plot 5 lb/a perennial rye, 211 - north 4/5 plot 5 lb/a peren. rye + 6 lb/a Arlington RC, 312 - north 1/3 plot 5 lb/a peren. rye + 6 lb/a Arlington RC, 403 - south 1/3 plot 5 lb/a peren. rye + 6 lb/a Arlington RC.
[2/] Seeding with hand operated cyclone seeder

APPENDIX IX.A. **LAKELAND AGRICULTURAL COMPLEX WICST INPUT/OUTPUT DATA - 1993**

Corn Treatments

Crop-93	Cont. Corn	Corn	Corn	Corn	Corn
Prev Crop	Corn	Soybean	Wheat/RC	Alfalfa II	Alfalfa I
Rotation	R1	R2	R3	R4	R5
Treatment	1	3	6	7	12
Plot #'s	101,210, 303,401	113,206, 311,410	111,208, 306,407	103,202, 310,411	105,207, 309,412
Primary Tillage	Chisel Plow 12/19/92	No-till	Chisel Plow Sweeps 5/8/93	Chisel Plow Sweeps 5/13/93	Chisel Plow Sweeps 5/8/93
Secondary Tillage	Mulchmaster 5/9,5/10/93	None	Mulchmaster 5/9,5/13/93	Mulchmaster 5/13,5/14/93	Mulchmaster 5/9,5/13/93
Planted	5/13/93	5/13/93	5/14/93	5/14/93	5/14/93
Variety	Pioneer 3563	Pioneer 3563	Pioneer 3563	Pioneer 3563	Pioneer 3563
Rate	32,000	32,000	32,000	32,000	32,000
Fertilizer					
Starter	180 lb/a 4-10-10	180 lb/a 4-10-10	None	180 lb/a 4-10-10	None
Nitrogen	150 lb N/a as 82-0-0 7/4/93	120 lb N/a as 28% 5/28/93	None	120 lb N/a as 28% [1/] 5/28/93	None
Manure	None	None	None	20 Ton/a 12/22/92	15 Ton/a 12/22/92
Pesticides	pre 5/20/93 Extrazine IIDF 2.5 lb/a Confidence 2 qt/a postemerge Buctril 1 pt/a 6/28/93 Counter 15G 10 lb/a with planter	prepl 5/11/93 Ranger 1.5 qt/a 2,4-D Hi-dep .5 pt/a pre 5/20/93 Dual 1.3 pt/a postemerge Buctril 1 pt/a 6/28/93	None	prepl 5/11/93 Ranger 1.5 qt/a 2,4-D Hi-dep .5 pt/a pre 5/20/93 Dual 1.3 pt/a postemerge Buctrol 1 pt/a 6/28/93	None
Rotary Hoe	None	None	#1 5/26/93 #2 6/1/93	None	#1 5/26/93 #2 6/1/93
Cult.	S-tine 7/5/93	S-tine 7/5/93	S-tine 6/23/93 7/5/93[2/] 7/13/93	S-tine 7/5/93	S-tine 6/24/93[2/] 7/5/93
Harvest	11/1/93	11/1/93	11/1/93	11/1/93	11/1/93
Yield	100 bu/a	101 bu/a	78 bu/a	113 bu/a	81 bu/a
Fall Practices	Chisel plow 11/8/93	None	Chisel plow 11/8/93	20 T/a manure 11/10/93 Chisel plow 11/11/93	15 T/a manure 11/9/93 Chisel plow 11/11/93
Crop-94	Corn	NR Soybean	WR Soybean	D.S. Alflafa	Oats/Alfalfa

[1/] Mistakenly applied nitrogen due to error on field plans.
[2/] Cultivations with no-till cultivator

APPENDIX IX.B. **LAKELAND AGRICULTURAL COMPLEX WICST INPUT/OUTPUT DATA - 1993**

Soybean and Wheat Treatments

Crop-93	Narrow Row Soybean	Wide Row Soybean	Wheat/ Red Clover
Prev. Crop	Corn	Corn	Soybean
Rotation	R2	R3	R3
Treatment	2	5	4
Plot #'s	108,203, 304,409	107,205, 307,406	109,204, 308,404
Primary	Chisel Plow 12/19/92	Chisel Plow 12/19/92	None
Secondary Tillage	Mulchmaster 5/9,5/10/93	Mulchmaster 5/9,5/10/93	None
Planting Date	5/12/93	5/12/93	9/27/92 Wheat 4/7/93 Rd Clov[1/]
Variety	Pioneer 9272	Kaltenberg 241	Arlington RC
Rate	199,500 seeds/a	156,000 seeds/a	180 lb/a Wheat 20 lb/a Rd Clov
Fertilizer	None	None	None
Pesticides	postemerge assure II 7 oz/a 6/29/93 Classic .3 oz/a Pinnacle .3 oz/a 28%N 1.3 gal/a 7/3/93	None	None
Rotary Hoe	None	#1 5/22/93 #2 5/26/93 #3 6/1/93	None
Cultivation	None	No-till 6/23/93 S-tine 7/5/93	None
Harvest	10/12/93	10/8/93	7/29/93
Yield	49 bu/a	32 bu/a	22 bu/a wheat 2.20 T/a straw
Fall Practices	None	Mulchmaster 10/8/93 No-till drill Merrimac w.wheat 150 lb/a 10/8/93	Mulchmaster (sweeps) 11/11/93
Crop-94	Corn	Wheat/Red Clover	Corn

[1/] Seeded with cyclone seeder on ATV.

APPENDIX IX.C. **LAKELAND AGRICULTURAL COMPLEX WICST INPUT/OUTPUT DATA - 1993**

Forage Treatments

Crop-93	D. Seeded Alfalfa	Estab. Alfalfa I	Estab. Alfalfa II	Oats/ Alfalfa	Estab. Alfalfa I	Pasture
Prev. Crop	Filler Corn	D.S. Alf.	Alfalfa I	Corn	Oats/Alf.	Pasture
Rotation	R4	R4	R4	R5	R5	R6
Treatment	10	9	8	11	13	14
Plot #'s	112, 214 301, 403	110,212, 302,414	102,209, 305,402	106, 211 312, 413	114,201, 313,405	104,213, 314,408
Primary Tillage	Chisel Plow 12/19/92			Chisel Plow 12/19/92		
Secondary Tillage	Mulchmaster 5/9, 5/10, 5/17/93			Mulchmaster 5/9, 5/10/93		
Planting Date	5/20/93	5/4/92 5/8/93 [1/]	4/26/91 5/8/93 [1/]	5/11/93	5/4/92 5/8/93 [1/]	5/30/90 4/7/93 [2/]
Variety	Magnum III	Magnum III	Magnum III	Pioneer-oats Magnum III-alf.	Magnum III	Timothy-Toro Brome-Badger RC-Marathon
Planting Rate	16 lb/a			80 lb/a oats 18 lb/a alf		20 lb/a Arl RC
Fertilizer Manure	20 ton/a 12/19/92	None	None	15 ton/a 12/19/92	None	grazing
Pesticides	Eptam 2 qt/a ppi 5/17	None	Ranger 1.5 qt/a 2,4-D Hi-dep 10/24/93	None	None	None
Harvest	8/27/93 hay	6/12/93 haylage 7/13/93 haylage 8/26/93 hay	6/12/93 haylage 7/13/93 haylage 8/26/93 hay	7/13/93 oatlage 8/27/93 hay	6/12/93 haylage 7/13/93 haylage 8/26/93 hay	began grazing 5/8/93
Yield	.50 tDM/a[3/]	2.87 tDM/a	2.61 tDM/a	1.42 tDM/a	3.37 tDM/a	727 lbt gain/a
Fall Practices	No-till drill[4/]	None	20 T/a manure 11/9/93	None	15 T/a manure 11/10/93	None
Crop-94	Alfalfa I	Alfalfa II	Corn	Alfalfa I	Corn	Pasture

[1/] No-till drilled into alfalfa plots with 12 lb/a Medium red clover, 3 lb/a annual rye grass.
[2/] Seeded with cyclone seeder on ATV.
[3/] One plot harvested, baler breakdown - 3 plots chopped back into field after rain.
[4/] Replanted areas where alfalfa was damaged by wet spring weather.

APPENDIX X.A. WICST Economics - Corn (R1 and R2) Arlington -1993

Rotation: 1 (Continuous Corn)
Crop: Corn — Site: Arlington
Year: 1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	123.8	Bu	$2.48	306.90
Total				$306.90

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (P3417)	0.41	Bag	81.050	33.23
Anhydrous	195.00	Lb	0.098	19.01
Starter (6-24-24)	100.00	Lb	0.076	7.60
Counter	9.00	Lb	1.600	14.40
Dual	2.00	Pt	7.125	14.25
Buctril	1.00	Pt	5.875	5.88
Surfactant	6.50	Oz	0.080	0.52
Drying (2¢/pt/bu to 15.5%)	123.75	Bu	29.23 %	33.89
Fuel	8.60	Gal.	0.63	5.42
Repairs	1.00	$	16.46	16.46
Interest	150.65	$	0.060	9.04
Total				$159.69

III. Gross Margin ($/Acre) : $147.21

Rotation: 2 (Corn-Soybeans)
Crop: Corn — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	129.8	Bu	$2.48	321.97
Total				$321.97

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (P3417)	0.41	Bag	81.05	33.23
Anhydrous	146.00	Lb	0.10	14.24
Starter	100.00	Lb	0.08	7.60
Dual	2.00	Pt	7.13	14.25
Buctril	1.00	Pt	5.88	5.88
Surfactant	6.50	Oz	0.08	0.52
Stinger	0.04	Plot	462.00	17.51
Drying (2¢/pt/bu to 15.5%)	129.83	Bu	33.70 %	47.22
Fuel	4.41	Gal.	0.63	2.78
Repairs	1.00	$	13.84	13.84
Interest	157.06	$	0.060	9.42
Total				$166.49

III. Gross Margin ($/Acre) : $155.48

APPENDIX X.A. **WICST Economics - Soybeans (R2 and R3) Arlington -1993**

Rotation: 2 (Corn-Soybeans)
Crop: Soybeans (NR) — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Soybeans	52.8	Bu	$6.29	331.95
Total				$331.95

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (P9272)	90.00	Lb	0.27	24.30
Pinnacle	0.25	Lb	28.35	7.09
Classic	0.25	Pt	17.70	4.43
Poast	1.50	Pt	11.88	17.81
Dash	2.00	Pt	0.49	0.97
Innoculum	1.50	Bu	0.49	0.74
Fuel	4.56	Gal.	0.63	2.87
Repairs	1.00	$	10.68	10.68
Interest	68.89	$	0.060	4.13
Total				$73.02

III. Gross Margin ($/Acre) : **$258.94**

Rotation:3 (Corn/Soybeans/Wheat)
Crop: Corn — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn @15.5%	87.10	Bu	$2.48	216.01
Total				$216.01

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3563)	0.41	Bag	81.05	33.23
Drying (2¢/pt/bu to 15.5%)	87.10	Bu	33.70 %	31.55
Fuel	9.52	Gal.	0.63	6.00
Repairs	1.00	$	16.06	16.06
Interest	86.84	$	0.060	5.21
Total				$92.05

III. Gross Margin ($/Acre) : **$123.96**

APPENDIX X.A. **WICST Economics - Wheat/Red Clover(R3) and Corn (R3) Arlington -1993**

Rotation:3 (Soybeans/Wheat)
Crop: Soybeans/WRow — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Soybeans	53.30	Bu	$6.29	335.26
Total				$335.26

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Kaltenberg 241)	60.00	Lb	0.26	15.60
Innoculum	1.00	Bu	0.49	0.49
Fuel	6.26	Gal.	0.63	3.95
Repairs	1.00	$	12.02	12.02
Interest	32.06	$	0.060	1.92
Total				$33.98

III. Gross Margin ($/Acre) : $301.28

Rotation:3 (Soybeans/Wheat)
Crop: Wheat/Clover — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Wheat @13%	28.63	Bu	$2.80	80.15
Straw	1.43	T	$50.00	71.62
Total				$151.78

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Wheat Seed (Merrimac)	2.50	Bu	7.00	17.50
RedClover (Arlington)	20.00	Lb	1.39	27.80
Buctril	1.00	Lb	4.75	4.75
Fuel	8.92	Gal.	0.63	5.62
Repairs	1.00	$	16.21	16.21
Interest	71.89	$	0.060	4.31
Total				$76.20

III. Gross Margin ($/Acre) : $75.58

APPENDIX X.A. **WICST Economics - D.S. Alfalfa (R4) and Alfalfa I (R4) Arlington -1993**

Rotation:4 (Direct Seed Alfalfa)
Crop: Direct Seed Alfalfa — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	1.64	Tdm	$53.75	88.15
Haylage	1.63	Tdm	$55.25	90.20
Total	3.27			$178.35

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Alfalfa Seed (MagnumIII)	15.00	Lb	$2.30	34.50
Eptam	2.00	Qt	$5.97	11.94
Fuel	11.93	Gal.	0.63	7.52
Repairs	1.00	$	11.86	11.86
Interest	65.82	$	0.060	3.95
Total				$69.77

III. Gross Margin ($/Acre) : **$108.58**

Rotation:4 (Direct Seed Alfa)
Crop Alfalfa I — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	0.68	Tdm	$54.00	36.45
Haylage	1.41	Tdm	$37.50	52.78
Haylage	1.62	Tdm	$58.00	93.82
Total				$183.05

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Perennial Rye	5.00	Lb	1.10	5.50
Alfalfa Seed (MagnumIII)	6.00	Lb	2.30	13.80
Fuel	14.67	Gal.	0.63	9.25
Repairs	1.00	$	15.66	15.66
Interest	44.21	$	0.060	2.65
Total				$46.86

III. Gross Margin ($/Acre) : **$136.19**

APPENDIX X.A. **WICST Economics - Alfalfa II (R4) and Corn (R4) Arlington -1993**

Rotation:4 (Direct Seed Alfa)
Crop: Alfalfa II — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	0.41	Tdm	$52.00	21.45
Haylage	1.17	Tdm	$35.50	41.54
Haylage	1.67	Tdm	$44.50	74.09
Total	3.25			$137.08

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Perennail Rye	5.00	Lb	1.10	5.50
Red Clover Seed (Arlington)	6.00	Lb	1.39	8.34
2,4-D	1.00	Pt	1.20	1.20
Banvel	0.50	Pt	7.75	3.88
Fuel	17.66	Gal.	0.63	11.13
Repairs	1.00	$	18.27	18.27
Interest	48.31	$	0.060	2.90
Total				$51.21

III. Gross Margin ($/Acre) : **$85.87**

Rotation:4 (Direct Seed Alfalfa)
Crop: Corn — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn (@15.5%)	165.1	Bu	$2.48	409.39
Total				$409.39

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (P3417)	0.41	Bag	$81.050	33.23
Dual	2.00	Pt	$7.125	14.25
Buctril	1.00	Pt	$5.875	5.88
Surfactant	6.50	Oz	$0.080	0.52
Starter	100.00	Lb	$0.076	7.60
Drying (2¢/pt/bu to 15.5%)	165.08	Bu	27.65 %	40.10
Fuel	9.07	Gal.	0.63	5.72
Repairs	1.00	$	16.74	16.74
Interest	124.03	$	0.060	7.44
Total				$131.47

III. Gross Margin ($/Acre) : **$277.91**

APPENDIX X.A. **WICST Economics - Oats/Alfalfa (R5) and Alfalfa I (R5) Arlington -1993**

Rotation:5 (Oats/Alfalfa)
Crop: Oats/A — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Oats	62.0	Bu	$1.50	92.96
Straw	1.5	Ton	$60.00	91.35
Total				$184.31

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Prairie Oat Seed	64.00	Lb	0.158	10.11
Magnum III (alfalfa)	15.00	Lb	2.300	34.50
Fuel	5.66	Gal.	0.63	3.57
Repairs	1.00	$	12.55	12.55
Interest	60.73	$	0.060	3.64
Total				$64.37

III. Gross Margin ($/Acre) : $119.94

Rotation:5 (Oats/Alfalfa)
Crop: Alfa I — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	1.17	Tdm	$50.75	59.12
Haylage	1.60	Tdm	$38.25	61.01
Haylage	1.89	Tdm	$54.75	103.48
Total				$223.61

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Red Clover Seed	1.70	Lb	$1.39	2.36
Perennial Rye Seed	3.09	Lb	$1.10	3.39
Fuel	17.19	Gal.	0.63	10.83
Repairs	1.00	$	17.73	17.73
Interest	34.32	$	0.060	2.06
Total				$36.37

III. Gross Margin ($/Acre) : $187.24

APPENDIX X.A. **WICST Economics - Corn (R5) and Pasture (R6) Arlington -1993**

Rotation:5 (Oats/Alfalfa)
Crop: Corn — Site: Arlington
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn @15.5%	119.10	Bu	$2.48	295.37
Total				$295.37

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3563)	0.41	Bag	81.05	33.23
Drying (2¢/pt/bu)	119.1	Bu	29.95 %	34.30
Fuel	10.32	Gal.	0.63	6.50
Repairs	1.00	$	19.41	19.41
Interest	93.44	$	0.060	5.61
Total				$99.05

III. Gross Margin ($/Acre) : $196.32

APPENDIX X.B. **WICST Economics - Corn (R1 and R2) Lakeland -1993**

Rotation: 1 (Continuous Corn)
Crop: Corn — Site: Walworth Co
Year: 1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	99.70	Bu	$2.48	247.26
Total				$247.26

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3563)	0.40	Bag	$74.22	29.69
Anhydrous	183.00	Lb	$0.11	19.22
Starter (4-10-10)	180.00	Lb	$0.05	9.54
Counter	10.00	Lb	$1.81	18.10
Confidence (Lasso)	2.00	Qt	$5.44	10.88
Extrazine	2.50	Lb	$3.92	9.80
Buctril	1.00	Pt	$5.97	5.97
Drying (2¢/pt/bu to 15.5%)	99.70	Bu	26.25 %	21.38
Fuel	8.18	Gal.	0.74	6.05
Repairs	1.00	$	17.00	17.00
Interest	147.63	$	0.060	8.86
Total				$156.49

III. Gross Margin ($/Acre) : $90.77

Rotation: 2 (Corn-Soybeans)
Crop: Corn — Site: Walworth Co
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	101.20	Bu	$2.48	250.98
Total				$250.98

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3563)	0.40	Bag	74.22	29.78
28% Nitrogen	39.00	Lb	0.59	22.82
Starter (4-10-10)	180.00	Lb	0.05	9.54
Ranger	1.50	Qt	7.55	11.33
2,4-D Hi-Dep	0.50	Pt	2.31	1.15
Dual	1.30	Pt	7.14	9.28
Buctril	1.00	Pt	5.97	5.97
Drying (2¢/pt/bu to 15.5%)	101.20	Bu	21.85	11.66
Fuel	4.49	Gal.	0.74	3.32
Repairs	1.00	$	13.46	13.46
Interest	118.30	$	0.060	7.10
Total				$125.40

III. Gross Margin ($/Acre) : $125.58

APPENDIX X.B. **WICST Economics - Soybeans (R2 and R3) Lakeland -1993**

Rotation: 2 (Corn-Soybeans)
Crop: Soybeans (NR) — Site: Walworth Co
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Soybeans	49.00	Bu	$6.29	308.21
Total				$308.21

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (P9272)	85.00	Lb	0.262	22.27
Assure II	7.00	Oz	1.013	7.09
Pinnacle	0.30	Oz	26.680	8.00
Classic	0.30	Oz	16.480	4.94
28% Nitrogen	1.30	Gal	0.700	0.91
Crop Oil	2.60	Pt	0.489	1.27
Innoculum	1.00		0.620	0.62
Fuel	5.00	Gal.	0.74	3.70
Repairs	1.00	$	13.81	13.81
Interest	62.62	$	0.060	3.76
Total				$66.38

III. Gross Margin ($/Acre) : **$241.83**

Rotation:3 (Soybeans/Wheat)
Crop: Soybeans/WRow — Site: Walworth Co
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Soybeans	32.3	Bu	$6.29	203.01
Total				$203.01

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed Kaltenberg -241	60.00	Lb	0.26	15.60
Innoculum	1.00	Acre	0.44	0.44
Fuel	6.31	Gal.	0.74	4.67
Repairs	1.00	$	16.47	16.47
Interest	37.18	$	0.060	2.23
Total				$39.41

III. Gross Margin ($/Acre) : **$163.60**

APPENDIX X.B. **WICST Economics - Wheat/Red Clover(R3) and Corn (R3) Lakeland -1993**

Rotation:3 (Soybeans/Wheat)
Crop: Wheat/Clover | Site: Walworth Co
Year:1993 | Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Wheat @13%	22.30	Bu	$2.80	62.44
Straw	2.20	Ton	$50.00	110.13
Total				$172.57

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Wheat Seed (Merrimac)	2.50	Lb	7.00	17.50
RedClover (Arlington)	20.00	Lb	1.70	34.00
Fuel	9.48	Gal.	0.74	7.02
Repairs	1.00	$	18.57	18.57
Interest	77.09	$	0.060	4.63
Total				$81.71

III. Gross Margin ($/Acre) : $90.85

Rotation: 3 (SB/Wheat/Corn)
Crop: Corn | Site: Walworth Co
Year:1993 | Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	77.73	Bu	$2.48	192.76
Total				$192.76

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3563)	0.40	Bag	74.22	29.78
Drying (2¢/pt/bu to 15.5%)	77.73	Bu	26.40 %	16.60
Fuel	9.18	Gal.	0.74	6.80
Repairs	1.00	$	16.87	16.87
Interest	70.05	$	0.060	4.20
Total				$74.25

III. Gross Margin ($/Acre) : $118.51

APPENDIX X.B. **WICST Economics - D.S. Alfalfa (R4) and Alfalfa I (R4) Lakeland -1993**

Rotation:4 (Direct Seed Alfalfa)
Crop: Direct Seeded | Site: Lakeland Ag Complex
Year:1993 | Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	0.50	Tdm	$18.50	9.30
Haylage	0.00	Tdm	$0.00	0.00
Total	0.50			$9.30
II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Alfa Seed (Magnum III)	32.00	Lb	3.26	104.32
Eptam 7E	2.00	Qt	5.70	11.40
Fuel	9.85	Gal.	0.74	7.29
Repairs	1.00	$	10.32	10.32
Interest	133.33	$	0.060	8.00
Total				$141.33
III. Gross Margin ($/Acre) :				($132.04)

Rotation:4 (Direct Seed Alfa)
Crop: Alfa 1 | Site: Lakeland Ag Complex
Year:1993 | Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	0.48	Tdm	$52.25	24.82
Haylage	0.88	Tdm	$55.00	48.26
Haylage	1.53	Tdm	$80.75	123.14
Total	2.88			$196.23
II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Red Clover	12.00	Lb	1.44	17.28
Rye Grass	3.00	Lb	0.55	1.65
Fuel	16.56	Gal.	0.74	12.25
Repairs	1.00	$	18.31	18.31
Interest	49.49	$	0.060	2.97
Total				$52.46
III. Gross Margin ($/Acre) :				$143.76

APPENDIX X.B. **WICST Economics - Alfalfa II (R4) and Corn (R4) Lakeland -1993**

Rotation:4 (Direct Seed Alfa)
Crop: Alfa 2 — Site: Lakeland Ag Complex
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	0.60	Tdm	$47.25	28.47
Haylage	0.63	Tdm	$57.25	36.07
Haylage	1.38	Tdm	$87.25	119.97
Total	2.61			$184.50

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Red Clover	12.00	Lb	1.44	17.28
Rye Grass	3.00	Lb	0.55	1.65
Manure	20.00	Ton	0.00	0.00
Ranger	1.50	Qt	7.55	11.33
2,4-D Hi Dep	0.50	Pt	2.31	1.15
Fuel	19.53	Gal.	0.74	14.45
Repairs	1.00	$	20.89	20.89
Interest	66.75	$	0.060	4.01
Total				$70.76

III. Gross Margin ($/Acre) : **$113.75**

Rotation:4 (Direct Seed Alfalfa)
Crop: Corn — Site: Lakeland Ag Complex
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	113.30	Bu	$2.48	280.98
Total				$280.98

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3563)	0.40	Bag	74.22	29.78
Starter (4-10-10)	180.00	Lb	0.05	9.54
Ranger	1.50	Qt	5.68	8.51
2,4-D Hi-Dep	0.50	Pt	3.62	1.81
Dual	1.30	Pt	5.93	7.71
Buctril	1.00	Pt	6.26	6.26
Manure	20.00	Ton	1.49	29.85
Drying (2¢/pt/bu to 15.5%)	113.30	Bu	21.85 %	13.75
Fuel	10.97	Gal.	0.74	8.12
Repairs	1.00	$	18.70	18.70
Interest	134.03	$	0.060	8.04
Total				$142.07

III. Gross Margin ($/Acre) : **$138.91**

APPENDIX X.B. **WICST Economics - Oats/Alfalfa (R5) and Alfalfa I (R5) Lakeland -1993**

Rotation:5 (Oats/Alfalfa)
Crop: Oats/Alfalfa — Site: Lakeland Ag Complex
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Oatlage	0.68	Bu	$45.25	30.54
Alfalfa	0.75	Tdm	$68.25	51.36
Total				$81.90

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Prairie Oat Seed	2.50	Bu	5.25	13.13
Alfalfa Seed (Magnum III)	18.00	Lb	3.26	58.73
Fuel	11.00	Gal.	0.74	8.14
Repairs	1.00	$	11.95	11.95
Interest	91.94	$	0.060	5.52
Total				$97.46

III. Gross Margin ($/Acre) : ($15.56)

Rotation:5 (Oats/Alfalfa)
Crop: Alfa 1 — Site: Lakeland Ag Complex
Year:1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Haylage	0.46	Tdm	$54.75	25.32
Haylage	0.97	Tdm	$56.75	55.19
Bales	1.94	Tdm	$82.75	160.54
Total	3.375			$241.05

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Rye Grass	3.00	Lb	0.55	1.65
Red Clover	12.00	Lb	1.44	17.28
Manure	15.00	Ton	0.00	0.00
Fuel	14.56	Gal.	0.74	10.77
Repairs	1.00	$	16.25	16.25
Interest	45.95	$	0.060	2.76
Total				$48.71

III. Gross Margin ($/Acre) : $192.33

APPENDIX X.B. **WICST Economics - Corn (R5) and Pasture (R6) Lakeland -1993**

Rotation: 5 (Oats/Alfalfa)
Crop: Corn — Site: Lakeland Ag Complex
Year: 1993 — Plots: Average across 4 plots

I. Gross Returns ($/Acre) :				Dollars
Product	Yield	Unit	Price	per acre
Corn	80.65	Bu	$2.48	200.01
Total				$200.01

II. Direct Costs ($/Acre) :			Price or	Dollars
Input	Amount	Unit	Factor	per acre
Seed (Pioneer 3578)	0.40	Bag	74.22	29.78
Manure	15.00	Ton	0.00	0.00
Drying (2¢/pt/bu to 15.5%)	80.65	Bu	25.33 %	14.83
Fuel	11.70	Gal.	0.74	8.66
Repairs	1.00	$	19.04	19.04
Interest	72.31	$	0.060	4.34
Total				$76.65

III. Gross Margin ($/Acre) : $123.36

APPENDIX XI. **Farmer-based Soil Health Scorecard**

FARMER–BASED SOIL HEALTH SCORECARD

WICST Farmer Version: Site # Arlington Rotation 5 [OAC] Average

This scorecard was developed as a result of interviews with 28 farmers in conjunction with the Wisc. Integrated Cropping System Trial by the University of Wisconsin's Soil Health Project. The scorecard evaluates descriptive and analytical properties of soil and non–soil (plant, animal & water) target systems to determine a soil's health status. The scorecard will assist both in the development of strategies to improve soil quality and build soil health based on farmer's working knowldge of the soil. When scoring your soil's health please:

1. Read each question completely
2. Choose the answer that best describes the soil health property in question
3. Enter your answer in the box provided
4. If a question does not apply to your farm, enter NA and go to the next question
5. Feel free to write any comments or explanations on the scorecard.

DRAFT

SOIL – Questions refer primarily to the plow layer		SCORE
Look		
1. EROSION		
Erosion is severe, considerable topsoil moved by water or wind, gullies formed	0 pt	
Moderate erosion, some signs of sheet and rill erosion, some topsoil blows	2 pt	4
No erosion evident, topsoil resists erosion by water or wind	4 pt	
2. EARTHWORMS		
No sign of worm activity, worms cannot be found	0 pt	
Few worm holes or castings, worms lacking in soil	2 pt	4
Worm holes and castings numerous, worms visible while plowing	4 pt	
3. STRUCTURE		
Soil is cloddy with big chunks, or dusty and powdery	0 pt	
Soil is lumpy or doesn't hold together	2 pt	4
Soil is crumbly, granular, holds together	4 pt	
4. INFILTRATION		
Water doesn't soak in, sits on top or runs off	0 pt	
Water soaks in slowly, some runoff or puddling after a heavy rain	2 pt	4
Water soaks right in, soil is spongy, no ponding	4 pt	
5. COLOR		
Soil color is light, dull grey, yellow or orange	0 pt	
Soil color is brown, grey, or reddish	2 pt	4
Soil color is dark black, brown, or grey	4 pt	
6. SURFACE MULCH		
Soil surface is clean, bare, all residue removed or buried	0 pt	
Soil surface has little residue, mostly buried	1 pt	1
Soil surface is trashy, lots of mulch left on top	2 pt	
7. SURFACE CRUST		
Surface is hard, cracked when dry, compacted	0 pt	
Surface is smooth with few holes, thin crust	1 pt	2
Surface doesn't crust, porous, dig easily with hand	2 pt	
8. SOIL DEPTH		
Subsoil is exposed or near surface	0 pt	
Soil is shallow, minimal topsoil	1 pt	NI
Soil is deep, lots of topsoil	2 pt	
Feel		
9. COMPACTION		
Soil is tight and compacted, can't get into it, thick hardpan	0 pt	
Soil packs down, thin hardpan or plow layer	2 pt	4
Soil stays loose, doesn't pack, no hardpan	4 pt	
10. FEEL		
Soil is mucky, greasy, sticky	0 pt	
Soil is smooth or grainy, compresses when squeezed	1 pt	NI
Soil is loose, fluffy, won't compress when squeezed	2 pt	

APPENDIX XI. **Farmer-based Soil Health Scorecard** (continued)

SOIL – Questions refer primarily to the plow layer		SCORE
Feel		
11. FRIABILITY		2
Soil is hard, dense or solid, can't break between two fingers	0 pt	
Soil is firm, breaks up between fingers under moderate pressure	1 pt	
Soil is soft, crumbles easily under light pressure	2 pt	
12. SOIL TEXTURE		NI
Texture is extremely sandy, clayey or rocky	0 pt	
Texture is too heavy or too light	1 pt	
Texture is loamy (silt, sand or clay loam)	2 pt	
Smell		
13. SMELL		1
Soil has a sour, putrid or chemical smell	0 pt	
Soil has no odor or a mineral smell	1 pt	
Soil has an earthy, sweet, fresh smell	2 pt	
Look/Feel		
14. TILLAGE EASE		0
Plow scours hard, soil never works down	0 pt	
Soil grabs plow, difficult to work, needs extra passes — AFTER HAY	2 pt	
Plow field in higher gear, soil flows & falls apart, mellow	4 pt	
15. DRAINAGE		4
Poor drainage, soil is often waterlogged or over saturated	0 pt	
Soil drains slowly, slow to dry out	2 pt	
Soil drains to field capacity quickly, water moves through it	4 pt	
16. WATER RETENTION		4
Soil drys out fast (droughty)	0 pt	
Soil is drought prone in dry weather	2 pt	
Soil holds moisture longer, gives and takes water easily	4 pt	
17. DECOMPOSITION		4
Residues and manures don't breakdown in soil, when plowed up they look the same	0 pt	
Slow rotting of residues and manures, does not completely break down in one year	2 pt	
Rapid rotting of residue and manures, part of soil after one year	4 pt	
18. SOIL FERTILITY		NI
Poor fertility, lean, nutrients don't move, potential is low	0 pt	
Fertility not in balance, soil is overextended, needs help	1 pt	
Fertility is balanced, nutrients available, potential is high	2 pt	
19. AERATION		NI
Soil is tight, closed, not porous	0 pt	
Soil is dense, has a few pores	1 pt	
Soil is open, porous, breaths	2 pt	
20. BIOLOGICAL ACTIVITY		NI
Soil shows little biological action, no signs of soil microbes	0 pt	
Minimal biological activity, few white worm–like threads, moss, algae	1 pt	
Biological activity high, plentiful white worm–like threads, moss, algae	2 pt	
Analytical –Values are for typical soils in SE Wisconsin and could vary with soil type.		
21. ORGANIC MATTER		2
Organic matter (humus) less than 2% or greater then 8%	0 pt	
Organic matter less than 4% or greater than 6%	2 pt	
Organic matter 4 to 6%	4 pt	
22. pH		4
Soil pH less than 6.4 or greater than 7.2	0 pt	
Soil pH 6.4 to 6.7 or 7.0 to 7.2	2 pt	
Soil pH 6.7 to 7.0	4 pt	
23. SOIL TEST – N, P & K		NI
Two or more nutrient levels very low, law of minimum at work	0 pt	
Soil test values are below recommended levels, need extra inputs	2 pt	
All nutrient levels at recommended levels	4 pt	

APPENDIX XI. **Farmer-based Soil Health Scorecard** (continued)

SOIL – Questions refer primarily to the plow layer — **SCORE**

Analytical

24. MICRONUTRIENTS		
Severe shortages of a trace mineral (Zinc, Sulfer, Boron, etc.)	0 pt	NI
Micronutrients at a minimal level or are not a concern	1 pt	
Levels of trace minerals are high and balanced	2 pt	
25. CALCIUM:MAGNESIUM RATIO		
Ca:Mg ratio is way out of balance, difficult to correct	0 pt	NI
Ca:Mg ratio is of no concern	1 pt	
Ca:Mg ratio is in balance	2 pt	

PLANT – Questions concern typical years with adequate rainfall and temperatures — **SCORE**

Look

26. CROP APPEARANCE		
Overall crop is poor, stunted, discolored, in an uneven stand	0 pt	NI
Overall crop is light green, small, in a thin stand	2 pt	
Overall crop is dark green, large and tall, in a dense stand	4 pt	
27. NUTRIENT DEFICIENCY		
Crop shows signs of severe deficiencies (blighted, streaky, spotty, discolored, leaves dry up)	0 pt	NI
Crop falls off or discolors as season progresses	2 pt	
Crop has what it needs, shows no signs of deficiencies	4 pt	
28. ROOTS		
Plant roots appear unhealthy (brown, diseased, spotted), poorly developed, balled up	0 pt	4
Plant roots are shallow, at hard angles, development limited, few fine roots	2 pt	
Plant roots are deep, fully developed with numerous fine root hairs	4 pt	
29. MATURE CROP		
Seedhead or pod misshapened, grain is not ripe, shrivelled, poor color	0 pt	NI
Seedhead small, unfilled, grain slow to ripen	1 pt	
Seedhead large, grain full, ripe, with good color	2 pt	
30. GROWTH RATE		
Crop slow to get started, never seems to mature	0 pt	1
Uneven growth, late to mature	1 pt	
Rapid, even growth, matures on time	2 pt	
31. RESISTS DROUGHT		
Plants drys out quickly, never recover	0 pt	2
Plants suffer in dry weather, slow to recover	1 pt	
Plants withstand dry weather, fast recovery	2 pt	
32. RESISTS PATHOGENS		
Plants damaged severely by pathogens (diseases & insects)	0 pt	2
Plants stressed by diseases and insects	1 pt	
No pathogens, or plants tolerate pests & disease well	2 pt	
33. LEAVES		
Leaves are yellow, discolored, few in number	0 pt	2
Leaves are small, narrow, light green	1 pt	
Leaves are full, lush, dark green	2 pt	
34. SEED GERMINATION		
Seed germination is poor, hard for crop to come out of ground	0 pt	NI
Germination is uneven, seed must be planted deeper	1 pt	
Seed comes up right away, good emergence	2 pt	
35. STEMS		
Stems are short, spindley, lodging often a problem	0 pt	NI
Stems are thin, leaning to one side	1 pt	
Stems are thick, tall, standing	2 pt	
36. FEED VALUE		
Feed has poor nutritional value (energy, protein, minerals), supplements must be use	0 pt	NI
Feed is unbalanced in energy, protein, or minerals, may require supplements	1 pt	
Feed is balanced, high in nutritional value, supplements used infrequently	2 pt	

APPENDIX XI. **Farmer-based Soil Health Scorecard** (continued)

PLANT – Questions concern typical years with adequate rainfall and temperatures

SCORE

Analytical –Values are typical for soils of SE Wisconsin

37. YIELD
   - Corn: less than 85 bbl/acre, Alfalfa: less than 2 ton/acre — 0 pt
   - Corn: 85 to 130 bbl/acre, Alfalfa: 2 to 6 ton/acre — 2 pt
   - Corn: greater than 130 bbl/acre, Alfalfa: greater than 6 ton/acre — 4 pt

   Score: 1

38. TEST WEIGHT
   - Grain test weight is low, takes a deduction — 0 pt
   - Grain test weight is average — 1 pt
   - Grain test weight is high — 2 pt

   Score: NI

39. COST OF PRODUCTION/PROFIT
   - Production and input costs high yet yields remain low — 0 pt
   - Increased level of inputs required to maintain yields — 1 pt
   - Yields dependable, high, maintained with low levels of inputs — 2 pt

   Score: NI

ANIMAL – Questions should not relate to improper housing, poor water or inclement weather.

SCORE

Look/Feel

40. HUMAN HEALTH
   - Human health is poor, recurrent health problems, recovery is difficult and long — 0 pt
   - Occasional health problems, slow recovery time — 1 pt
   - Human health is excellent, resists diseases, long life, quick recovery time — 2 pt

   Score: NI

41. ANIMAL HEALTH
   - Continuous animal health problems, poor performance and production — 0 pt
   - Occasional animal health problems, performance average — 1 pt
   - Animal health excellent, performance and production exceptional — 2 pt

   Score: NI

42. WILDLIFE
   - Signs of wildlife rare, animals do not appear well — 0 pt
   - Infrequent signs of wildlife; deer, turkey, frogs etc. uncommon — 1 pt
   - Wildlife is abundant, gulls behind plow; songbirds, turkey, deer are common — 2 pt

   Score: NI

WATER

SCORE

Analytical

43. CHEMICALS IN GROUNDWATER
   - Chemicals detected in ground water above allowable standards — 0 pt
   - Chemicals detected in ground water below allowable level — 1 pt
   - No chemicals present in ground water — 2 pt

   Score: NI

Look

44. SURFACE WATER APPEARANCE (open water flowing from fields – lakes, marshes, rivers, etc.)
   - Surface water is muddy, with slimy green scum — 0 pt
   - Surface water is brownish with dirt and silt — 1 pt
   - Surface water is clear and clean — 2 pt

   Score: NI

Scoring Procedure:

Column 1 Total scorecard for each target system

Column 2 Determine the maximum score possible for the questions answered.

Column 3 Score: Divide Col. 1 by Col. 2 and multiply by 100%.

Column	1	2	3
Target System	Your Score	Possible Score	SCORE
Soil	48	56	86%
Plant	14	18	78%
Animal	–	–	-
Water	–	–	–
Totals	62	74	84%

APPENDIX XII. **WICST Corn and Soybean Populations - 1991-1993**

A. Arlington Agricultural Research Station

Year	1991	1992	1993
	------	plants/acre	------
Corn R1[1/]	27,150	27,750	30,850
Corn R2	26,555	28,650	30,800
Corn R3		24,700	20,800
Corn R4			32,300
Corn R5			27,500
Soybean R2[2/]	132,741	118,547	179,823
Soybean R3[3/]	98,746	70,350	135,250

[1/] Corn - planted at 32,100 seeds/a in 1991 and 1992, and 32,500 seeds/a in 1993.
[2/]Narrow row soybean - planted at 235,000 seeds/a.
3/ Wide row soybean - planted at 156,000 seeds/a.

B. Lakeland Agricultural Complex

Year	1991	1992	1993
	------	plants/acre	------
Corn R1[4/]	30,700	29,050	30,150
Corn R2	29,500	24,550	29,900
Corn R3		24,250	21,100
Corn R4			31,250
Corn R5			21,400
Soybean R2[4/]	116,553	97,000	139,228
Soybean R3[6/]	117,633	122,952	86,950

[4/] Corn - planted at 32,000 seeds/a.
[5/] Narrow row soybean - planted at 220,000, 196,000 and 222,000 seeds/a in 1991, 1992, and 1993, respectively.
[6/] Wide row soybean - planted at 140,000, 155,000, and 156,000 seeds/a in 1991, 1992, and 1993, respectively.

APPENDIX XIII. **WICST Fall Legume Nitrogen for following Corn Crop.**

A. Arlington Agricultural Research Station

Year	Rotation	Crop	Foliage		Roots		Total
			DM	N	DM	N	N
			lb/a	%	lb/a	%	lb/a
1991	3	Red Clover	1852	3.24	2604	2.63	128
1992	3	Red Clover	2102	2.89	1816	2.72	110
1992	4	Alfalfa	2697	2.03	1767	2.27	95
1992	5	Alfalfa	2090	3.42	3352	2.29	148
1993	3	Red Clover	2811	2.81	1314	3.18	119
1993	4	Alfalfa[1/]	1867	2.91	1233	3.36	94
1993	5	Alfalfa[1/]	1614	4.05	1443	2.18	97

B. Lakeland Agricultural Complex

Year	Rotation	Crop	Foliage		Roots		Total
			DM	N	DM	N	N
			lb/a	%	lb/a	%	lb/a
1991	3	Red Clover	669	3.12	916	2.63[2/]	45
1992	3	Red Clover	3316	2.52	2984	2.58	161
1992	4	Alfalfa	977	4.25	2731	1.87	93
1992	5	Alfalfa	1018	4.24	2627	1.91	93
1993	3	Red Clover	2687	3.24	1224	2.90	123
1993	4	Alfalfa[1/]	2043	3.46	1251	2.74	104
1993	5	Alfalfa[1/]	2127	3.18	1222	2.72	101

[1/] Spring seeded with red clover because of severe winterkill to alfalfa.
[2/] Root N was not tested, used same % root N as at Arlington.

APPENDIX XIV. **Agricultural Enterprises: 1987 and 1992**

J.L. Posner and W.E. Saupe*

Agricultural enterprises in Wisconsin have continued to grow fewer in number and larger in size. Tables a and b list some farm characteristics taken from the 1987 and 1992 Census of Agriculture. The acreage data is from the 1988 and 1993 seasons. The columns represent State data, Major Land Resource Area Data (MLRA 95b; our general target area), as well as the situation around the Arlington Agricultural Research Station (Dane/Columbia Counties) and the Lakeland Agricultural Complex (Walworth Co.).

The south-eastern part of the State (MLRA 95b) contains 26% of Wisconsin's farms and dairy is an important enterprise on about one-third of them. Average production per cow is approximately 15,200 pounds/yr. The remaining farms are cash grain, vegetable and tree crop farms. Nearly 50% of Wisconsin's corn for grain soybeans, wheat and processing crops come from this area. Table c highlights some of the characteristics of cash grain farms in Wisconsin. Approximately one-third of them have greater than $20,000 in sales. Farms in MLRA 95b have slightly higher total sales than the State average and the two learning centers are in Counties with significantly higher farm values than the State average.

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Table a. Wisconsin Farm Enterprise Statistics, 1987.

	State	MLRA 95b[3]	Columbia County	Walworth County
No. of Farms[1]	75,131	19,663	1,513	980
Farms > 180 acres[1]	46%	38%	41%	40%
% of all farms with milk cows[1]	50%	40%	32%	30%
Ave No. cows/farm[1]	47	53	61	50
Acres Corn-grain[2]	2,800,000	1,046,000	109,000	82,000
Acres Corn-silage[2]	730,000	203,300	13,700	9,100
Acres Alfalfa hay[2]	2,800,000	599,500	38,500	20,100
Acres Soybean[2]	330,000	197,050	11,200	25,000
Acres Procerssing Crops[2]	326,800	175,800	15,400	10,800
Acres Winter Wheat[2]	85,000	64,300	3,200	4,200
Market value of all Ag Products per farm[1]	$65,351	$72,030	$64,162	$82,263

[1] 1987 Census of Agriculture Vol 1 part 49, Wisconsin: State and County Data. US Dept. of Comerce, Bureau of Census. US Govt. Printing Office, Washington, DC. Issued, March 1989.

[2] Agricultural Statistics - Wisconsin 1988. National Agricultural Statistics Service, USDA. Processing crops include green peas, sweet corn and snapbeans.

[3] Includes Calumet, Columbia, Dane, Dodge, Fond du Lac, Green Lake, Jefferson, Kenosha, Milwaukee, Ozaukee, Racine, Rock, Sheboygan, Walworth, Washington, Waukesha, and Winnebago counties.

Table b. Wisconsin Farm Enterprise Statistics, 1992.

	State	MLRA 95b[3]	Columbia + Dane Counties	Walworth County
No. of Farms[1]	67,959	17,722	4,082	868
Farms > 180 acres[1]	46%	35%	40%	40%
% of all farms with milk cows[1]	44%	35%	32%	25%
Ave. Milk production/cow (#)[4]	14,781	15,189	15,271	14,500
Ave No. cows/farm[1]	50	58	61	63
Acres Corn-grain[2]	2,950,000	1,154,200	318,600	100,500
Acres Corn-silage[2]	860,000	216,300	44,100	9,100
Acres Alfalfa hay[2]	2,300,000	456,900	96,800	15,200
Acres Soybean[2]	750,000	381,200	58,500	46,500
Acres Procerssing Crops[2]	326,200	177,500	31,500	9,250
Acres Winter Wheat[2]	145,000	105,050	15,250	7,400
Market value of all Ag Products per farm[1]	$77,395	$87,147	$91,888	$106,098

1 1992 Census of Agriculture Vol 1 part 49, Wisconsin: State and County Data. US Dept. of Comerce, Bureau of Census. US Govt. Printing Office, Washington, DC. Issued, February 1994.

2 Wisconsin Agricultural Statistics - 1993. National Agricultural Statistics Service, USDA. Processing crops include green peas, sweet corn and snapbeans. Alfalfa hay, corn-grain and corn-silage in acres harvested; all others in acres planted.

3 Includes Calumet, Columbia, Dane, Dodge, Fond du Lac, Green Lake, Jefferson, Kenosha, Milwaukee, Ozaukee, Racine, Rock, Sheboygan, Walworth, Washington, Waukesha, and Winnebago counties.

4 Wisconsin Dairy Summary, 1994. Wisconsin Agricultural Statistics Service, WDATCP, June, 1994.

Table c. Selected Characteristics of Wisconsin Cash Grain Farms[1]

	Number of Farms	Harvested Cropland (acres)
All Farms	67,959	130
Crop Farms	20,724	115
Cash Grain Farms[2]	7,234	187
By gross sales:		
<$20,000	4,563	
$20,000 to $99,999	1,938	
$100,000 to $249,999	476	
$250,000 or more	237	
By crop acres harvested:		
1-49	2,413	
50-99	1,757	
100-199	1,392	
200-499	992	
500-999	438	
1000-1999	204	
2000 or more	38	
Total cash grain farms	7,234	

1 Source: 1992 Census of Agriculture

2 Sale of corn, soybeans, and wheat comprise more than half of total sales in Cash Grain farms