

**Four Tillage Methods for Soybeans
Annual Report
North Central Sustainable Agriculture Research & Education Program**

Date: December 15, 2001

Title: Integrating Organic Soybean Production following Conservation Reserve Program (CRP) Land into Sustainable Farming Systems

Project No.: LCN 99-160

Summary:

Four tillage methods in a randomized complete block arrangement with four replications were investigated for effects on organic soybean production following CRP land in 1999 and 2000 at the ISU McNay Farm in Chariton, Iowa: Fall moldboard plowing; Fall Kverneland® plowing; Fall and spring tillage with a Howard Rotavator®; and Spring moldboard plowing. In 2000, a full three-year crop rotation was added to each system to meet certified organic requirements. Plots were laid. All organic soybean systems yielded well above the county average in 1999 and 2000 (average of 56 bu/acre). Soil quality (organic matter carbon) returned to pre-plowing levels after three weeks. In 2001, a wet spring created conditions for lower yields of 28 bu/A, which met county averages. Economic returns in the certified organic soybeans were 180% above conventional in 2001.

Type of Report: Annual/Second-year Report

Project Coordinator: Dr. Kathleen Delate, Assistant Professor, Depts. of Horticulture and Agronomy, Iowa State University, Ames, Iowa 50011, 515-294-7069/kdelate@iastate.edu

• **Team Members/ Co-Principal Investigators:**

- Dr. Cynthia Cambardella, Soil Scientist, USDA National Soil Tilth Lab., Ames, Iowa
- Jim Secor, Farm Supervisor, ISU McNay Research & Demonstration Farm, Chariton, Iowa
- Ms. Dorothy O'Brien, O'Brien and Pelton Farm, Clinton, Iowa
- Mark Carlton, ISU Field Crop Specialist, Albia, Iowa
- Robert Hartzler, Professor, Iowa State University, Dept. of Agronomy, Ames, IA
- Matt Liebman, Associate Professor, Iowa State University, Dept. of Agronomy, Ames, IA
- Lori Altheide, Soil Conservationist, Natural Resources Conservation Services, Ottumwa, Iowa

Duration of Project: Two years (FY 00-01)

Project Status: First-time Recipient

ABSTRACT

“Integrating Organic Soybean Production following Conservation Reserve Program (CRP) Land into Sustainable Farming Systems”

Project Contact: Kathleen Delate, Iowa State University

Organic farming has increased to an \$8 billion industry in the U.S. and continues to expand approximately 20% annually. In Iowa alone, organic acreage has increased from 13,000 in 1995 to 150,000 in 1999. Across the North Central region, there has been a great interest in planting organic soybeans on Conservation Reserve Program (CRP) land, where up to a 400% premium can be obtained compared to conventionally raised soybeans. Regulation of soil organic matter through additions of plant residues and proper crop rotations will determine the long-term sustainability of the system. The Objectives of this research and education program included the following: (1) Establish plots dedicated to organic farming research on CRP land; (2) Implement production and management regimes for opening CRP land and for weed control in organic systems on CRP land; (3) Evaluate the biological and economic outcomes of the different systems; and (4) Promulgate technology transfer through demonstrations/Field Days and publications for area farmers and agricultural professionals. The Methods adopted for this project included the establishment of a long-term agroecological research (LTAR) site in southeast Iowa. Plots were established at the Iowa State University McNay Research and Demonstration Farm in Chariton, Iowa, in a randomized complete block arrangement with four treatments and four replications on CRP land. Treatments consisted of four primary tillage methods: Fall moldboard plowing; Fall Kverneland® plowing; Fall and spring tillage with a Howard Rotavator®; and Spring moldboard plowing. Soil samples were taken pre- and post-harvest to determine physical and chemical changes in the system. Sampling for plant performance, weeds, insects and nematodes followed methods developed for the all LTAR sites. Results from the McNay Farm were very encouraging in 1999 and 2000. All organic soybean systems yielded well, averaging 49.3 bushels/acre in 1999 and 56.4 bushels/acre in 2000. These yields were above the county average in both years. Yields were greatest in the spring-plowed plots in 1999 and 2000. Soil quality (organic matter carbon) returned to pre-plowing levels after three weeks. In 2001, a wet spring created conditions for lower yields of 28 bu/A, which met county averages. Economic returns in the certified organic soybeans were 180% above conventional in 2001. Soybean grain quality was also high in all systems. Protein content averaged 42% in 2000 and 36% in 2001.

INTRODUCTION

Organic farming has increased to an \$8 billion industry in the U.S. and continues to expand approximately 20% annually. In Iowa alone, organic acreage has increased from 13,000 in 1995 to 120,000 in 1998 (IDALS, 1998). Across the North Central region, there has been a great interest in planting organic soybeans on Conservation Reserve Program (CRP) land, where up to a 400% premium can be obtained compared to conventionally raised soybeans (Delate et al., 1999). Farmers are able to by-pass the three-year transition period between chemical and certified organic land if the CRP land has not been sprayed. CRP conversion to organic production and the issue of long- vs. short-term rotations continue to top the list of research needs for the Iowa organic farming community. Several options confront farmers interested in making the transition from CRP land to organic production, including fall plowing vs. spring plowing, and winter rye as a cover crop vs. no cover.

Both the CRP program and organic farming practices strive to preserve soil structure and quality on erodible lands, and protect waterways from silting and runoff. Compliance with soil conservation plans is mandatory in the development of ideal cropping systems (Phillips et al., 1997). Regulation of soil organic matter through additions of plant residues and proper crop rotations will determine the long-term sustainability of the system. Farmers interested in transitioning some or all of their CRP land into organic production require information on best management practices for these systems. Once the transition to sustainable systems is complete, comparable yields to conventional systems can be obtained if ideal management is followed (NRC, 1989).

CRP conversion will alter existing ecosystem processes, such as nutrient cycling and biological control. Tillage operations can impact soil structure and soil biological cycles (Hanna et al., 1994). The mineralization of soil organic matter in CRP land may lead to nutrient deficiencies in subsequent crops. Grassland herbivores may switch hosts and colonize agronomic species, impacting yields and subsequent cropping practices (Brenneman et al., 1985). Regarding effects of a rye cover crop on pest populations, varied impacts were reported, depending on insect species (Smith et al., 1988). While Hammond (1990) found increased damage from phytophagous insects with cover crops, Minton (1992) found that rye cover decreased feeding from pestiferous nematodes and increased yields in soybeans. Soybean yields were greatest following rye, barley, or wheat (LeMahieu and Brinkman, 1990). Liebel et al. (1992) employed a rye cover tilled two weeks prior to planting to provide a similar level (90%) of weed control as herbicides in soybean production; and Ateh and Doll (1996) reported that rye killed 45 days after soybean planting could provide adequate weed control without reducing soybean yields. Results were mixed, depending on weather, in dry bean production systems with rye (Liebman et al. 1995). Through this project, research has begun to evaluate methods to maintain soil organic matter, minimize nutrient loss in CRP-converted organic systems, and mitigate pests (insects, weeds, diseases, nematodes).

OBJECTIVES

1. Establish plots dedicated to organic farming research on CRP land
2. Implement production and management regimes for opening CRP land and for weed control on conventional and organic systems on CRP land
3. Evaluate the biological and economic outcomes of the different systems
4. Promulgate technology transfer through demonstrations/Field Days and publications for area farmers and agricultural professionals.

ACCOMPLISHMENTS

Materials and Methods

The McNay Memorial Research Farm dedicated approximately two acres of a five-year old forage field (bromegrass and alfalfa) for this long-term project. Bromegrass predominated in the field, as is typical of CRP land in this area of the state.

Experimental Design

Forty-eight plots (four tillage treatments, three crops and four replications), measuring 30 x 60 ft. each, were laid out in a randomized complete block design in September, 1999. The initial plowing of the CRP land consisted of the following treatments: Treatment 1 = fall moldboard plowing, 2 = spring moldboard plowing; 3 = Kverneland® plowing (fall); and 4 = Howard Rotavator® (fall and spring). In 2000, a rotation of corn-soybean-oats underseeded with red clover was initiated to meet certified organic requirements. Each crop of the rotation was planted each year beginning in 2000.

Tillage and Mechanical Operations

Plots that were fall plowed in 1999 (Fall Moldboard and Kverneland-plowed) were retained as fall plowed plots in 2000 and 2001. All fall tillage for the 2001 season was accomplished by December 4, 2000. Winter rye was broadcast on corn plots with a three-point mounted spreader on October 6, 2000, at a rate of one bushel per acre to serve as a ground cover to prevent erosion and mitigate weed populations in 2001 soybean plots. The rye was mowed on May 15, 2001, but not disked until June 28-29, due to an extremely wet spring. Manure was applied to all plots going to corn at a rate of 5,000 lb/acre on March 25, 2001. 'Blaze' oats and 'Cherokee' red clover were planted on April 25, 2001 at a rate of 2 bu/ac and 12 lb/ac, respectively. Soybeans (Pioneer 9305) were planted at a population of 175,000 plants/acre on June 29, 2001. The corn variety Pioneer 35P12 was also planted on June 29, at a rate of 30,000 plants/acre. Corn and soybean plots were rotary-hoed for weed control on July 2 and July 12, and row cultivated on July 27, August 5 and August 27. Soybean plots were "walked" (large weeds removed by hand) on August 27, per local organic practices to remove any potentially staining weeds prior to harvest. Oats were harvested on July 24, 2001. A separate soybean plot was flamed on August 20. Corn and soybeans were harvested with a combine on November 6, 2001.

Sampling

Soil samples (five random samples per plot) were taken on November 17, 1999, and on May 9, 2000 at depths of 0-4" and 4-8", using methods described by Cambardella (1994) for the Neely-Kinyon LTAR site. Post harvest soil sampling occurred on November 7, 2001, at the same depths. Sampling for soil, plant performance, weeds, insects and nematodes followed methods developed for the Neely-Kinyon LTAR site (Delate, 1999). Crop stand counts were taken on July 17, 2001 (18 days after planting). Weed counts (3 square meter quadrats per plot) were taken on July 17. Weed counts were also taken on August 27, 2001, in the soybean flame weeding trial. Bean leaf beetles, which are associated with the soybean staining disease complex, were sampled in soybean plots on July 23, 2001, by sweeping 20 times per plot with a 15 inch diameter net. Corn borer populations were sampled by removing 3 randomly selected corn whorls per plot, and recording number of corn borer feeding holes and actual larvae on July 23. Soybean cyst nematodes were analyzed by sampling 3-6 inch soil cores per soybean plot for presence of eggs on October 19. Corn stalks were collected on October 19 for stalk nitrate analysis. Corn and soybeans were analyzed for protein, carbohydrates, fiber, and oil through the Iowa State

University Grain Quality Laboratory in the Department of Food Science. A 250-gram sample of harvested soybeans was analyzed from each plot for percentage of stained soybeans (soybeans with a tan, brown or mottled appearance).

RESULTS AND DISCUSSION

An extremely wet spring in southeast Iowa resulted in a very late planting date (June 29, compared to May 16 in 2000). Consequently, lower than normal yields were obtained throughout the region. Plant populations were reduced significantly by tillage operations in both corn and soybeans. Although there were no significant differences among treatments in corn stand counts at 18 DAP (Figure 1), there were significant differences among tillage treatments in soybean stand counts (Figure 2), with fall-plowed plots retaining higher plant populations than spring-plowed plots. It is not clear if these differences were the result of differential rotary-hoeing in the plots, or soil texture changes from spring plowing. Early weed counts in corn and soybeans demonstrated no significant differences among treatments in grass or broadleaf weed populations (Figures 3 & 4). Late season weed populations in soybean showed significantly higher levels of grasses in Rotovator® treated plots compared to all other treatments (Figure 5).

No significant yield differences were determined among treatments in oat or soybean plots. Organic oats averaged 62 ± 2.7 bu/ac and soybeans averaged 27 ± 5.3 bu/ac, which were comparable to county averages (Figures 6 & 7). Significantly greater corn yields were obtained in Rotavator® plots (113 ± 4 bu/ac) compared to the fall plowed (73.5 ± 15) and spring plowed plots (94 ± 7.6) (Figure 8).

Propane flame burning significantly decreased grass weed populations in soybean plots (Figure 9). Corn borer populations were below economic threshold levels in 2001 (Figure 10), but significantly greater damage was detected in the Kverneland plots. Bean leaf beetle populations were below 2000 levels (Figure 11), with no overall significant differences among treatments. Soybean staining, caused by bean pod mottle virus and other fungi, did not differ among treatments (Figure 12). There were no significant differences among treatments in corn or soybean grain quality in 2001 (Figures 13 & 14). There were no soybean cyst nematode eggs detected in any samples.

Soil quality analysis (Tables 1 and 2) identified that moldboard plowing released five times more particulate organic matter carbon (POM-C) than the other two tillage treatments, with pre-plowing levels at ~ 4.0 Mg/ha POM-C, and three weeks later, reaching ~ 20.0 Mg/ha. In the other tillage methods, POM-C was two to three times higher at that time. Soil quality parameters for 2001 are currently undergoing analysis.

Results from the CRP experiments demonstrated excellent production of high quality organic soybeans on land following CRP in 1999 and 2000. Corn and oat yields were also above average. All crops in the area suffered from a wet spring in 2001, which led to organic systems yielding similarly to county averages. We were pleased to obtain excellent yields and grain quality in soybean plots that were spring plowed as opposed to fall plowed. Spring plowing will allow for a vegetative cover during the winter and avoidance of soil erosion associated with fall plowing. Organic farmers in the Midwest, however, prefer fall plowing because of several reported reasons:

- Farmers normally have more time for plowing in the fall than in the spring when other tillage, planting and compost-spreading activities occur
- Fall plowing allows for a more complete break-up of soil through the freezing and thawing in winter, and
- Wet springs may preclude spring plowing.

For these reasons, we will continue this experiment, using funds from USDA, in order to determine yield and weed differences in the case of poor weather in the spring. Flame burning significantly lowered grass weed populations, but there was no effect on yield. We have seeded foxtail in selected plots to monitor exact weed populations in 2002.

Current economics (2001) dictate the superior economic value of certified organic soybeans (\$14/bu) compared to organic corn (\$3.20/bu) or organic oats (\$2.25/bu). In addition, compared with corn crop demands, soybeans can produce adequately on poorer soil, typical of CRP land. Corn yields were excellent in 2000, however, with returns for certified organic corn totaling \$830/acre (before costs). Returns for certified organic soybeans in 2001 were 180% above conventional soybeans. Complete economic analysis for all crops is underway with ISU economists, Mike Duffy and Craig Chase (Chase & Duffy, 1991).

Excellent yields in 1999 and 2000 demonstrated favorable N mineralization to support corn and soybean crops, which may have increased during tillage operations. N-mineralization and nitrate-N rates remained adequate during the conversion period from CRP to crop production.

IMPACTS OF THE RESULTS

Farmers have been involved in this project from its inception. The Leopold Center for Sustainable Agriculture supported Organic Farming Focus Groups in 1998 where the idea for evaluating CRP land into organic production originated. Approximately 7,000 people were made aware at 3 Field Days from 1999-2001 and presentations about the benefits of spring tillage and winter rye cover crops, in addition to other sustainable and organic agricultural practices. The farmers involved in these trials have adopted sustainable practices of using winter rye cover crops. A publication on "Growing Organic Soybeans on CRP Land" has been developed (ISU Extension Organic Agriculture Series). Overall outcomes of the entire Organic Program (the CRP project is included in all activities) are listed below.

I. Output Indicators

Generating Basic Information

- Number of research/demonstration plots established to develop sustainable/organic systems: 13
- Number of research/extension publications in sustainable/organic horticulture/agronomy: 15
- Number of grants to supplement research and demonstration efforts: 12

Engagement/Application

- Number of producers utilizing sustainable/organic practices: 353
- Number of acres in certified organic production: 150,000
- Number of Community Supported Agriculture projects (CSAs) active: 35
- Number of diversified or alternative community marketing systems or alliances established: 5
- Number of trained or updated key agricultural professionals in sustainable agriculture: 35
- Number of educational meetings, field days, workshops, one-on-one contacts, phone contacts: 268
- Number of mass media dissemination and direct teaching events: 7

II. Outcome Indicators:

- Percentage improvement in soil quality as a result of sustainable/organic practices: 10%
- Percentage reduction of harmful contaminants (excess nutrients and toxic chemicals) in Iowa waterways and groundwater: 44%
- Percentage new products (out of total market) for the value-added market: 2%
- Percentage income increase for family farmers from adoption of sustainable/organic practices: (Long-range determination underway in 2001)

Publications with Information from this Project:

(* represents availability on the Web)

Funding supported one graduate student in 1998-99 (William Inman) and provided support for other student assistants on this project.

Delate, K. 2001. Using an agroecological approach to farming systems research. Accepted for HortTechnology (#1413)

*Delate, K., C. Cambardella and J. Secor. 2001. Feasibility of Organic Soybean Production following CRP land. Iowa State University. McNay Research and Demonstration Farm Progress Report, College of Agriculture, Iowa State University, Ames, IA.

*Delate, K. 2000. Organic Agriculture. Submitted as PM publication to Extension Communications. Expected release date: 8/2001

*Delate, K. 2000. Weed Management for Organic Farmers. Submitted as PM publication to Extension Communications. Expected release date: 8/2001

*Delate, K. 2000. Soil Management for Organic Farmers. Submitted as PM publication to Extension Communications. Expected release date: 8/2001

*Delate, K. 2000. Growing Organic Soybeans on CRP Land. Submitted as PM publication to Extension Communications. Expected release date: 8/2001

- *Delate, K. and D. Muenchrath. 2000. Organic Farming Systems. Cropping Systems Management and Crop Ecology-Agronomy 531. Department of Agronomy, Iowa State University, Ames, IA.
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- Delate, K.M. 2000. The Sustainability of Organic Production: A Model for Rural Development. World Bank Sustainable Agriculture Conference, April 10, 2000, Iowa State University, Ames, IA.
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- Delate, K. 1999. Targeting the Premium Market: Organic Crops for Iowa. Integrated Crop Management Conference Proceedings, November 17, 1999, Iowa State University, Ames, IA.
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- Delate, K. 1997. Organic Agriculture. Integrated Crop Management Conference Proceedings, November 17, 1997, Iowa State University, Ames, IA.

Many articles appeared in the popular press on the Organic Program at ISU, including the CRP Project.

Education and Outreach on this Project:

K. Delate made 197 presentations on organic production, agroecological research, and organic marketing to an audience of approximately 10,000 people from 1998-2000. This included the development of 17 slide shows and 4 publications to use at such meetings. The fact sheets have been submitted to become permanent numbered Extension publications. Twenty-five Field Days, where this project was discussed, were held from 1998 to 2000 to an audience of approximately 1,650 Iowa and Midwest producers/Extension staff. Included in these Field Days were the development of full-color fact sheets and media packages. Field Days were held at the McNay CRP trial in 1998, 1999, and 2000, where a total of 225 people participated in a discussion of trial

results with K. Delate and cooperators. Other Extension activities around this research are discussed below.

Producer/Extension Workshops

TOOLBOX TRAINING FOR ORGANIC AGRICULTURE

On August 22-23, 2000, a tri-state training on organic agriculture was held in Greenfield and Orient, Iowa. This training focussed on organic principles and practices for 35 Extension specialists in Iowa, Missouri, and Wisconsin.

ORGANIC CROP PRODUCTION IOWA COMMUNICATION NETWORK (ICN) COURSE

In the fall of 1999, I developed the first Organic Crop Production ICN course for Extension and ISU university credit (AGRON/HORT 494X) for Spring semester 2000. The total attendance for the course was 168 participants, including 24 ISU students. An Organic Agriculture Gateway webpage was created with assistance from the Brenton Center. Completion of the webpage is anticipated in January 2002.

Upper Midwest Organic Farming Intensive Workshop

Based on request from organic farmers and agricultural professionals in the Midwest, a six-hour workshop entitled "The Organic University" was organized for March 23, 2001, in La Crosse, Wisconsin. I was responsible for a course on "Resources for Organic Farmers" that included publications, video tapes, farmer contacts, and organizations supporting organic producers in terms of funding and research initiatives. My course involved Extension personnel from the Universities of Minnesota and Wisconsin, along with agricultural professionals from lending agencies. Regional attendance for this workshop was estimated at 400 participants.

Cooperative Efforts/Team Members:

Working with cooperators, including Dr. Cynthia Cambardella of the USDA National Soil Tilth Lab.; Lori Altheide of the local NRCS office; Mike Duffy (ISU Economics); Dick Thompson (Practical Farmers of Iowa); the ISU Research & Demonstration farm staff (Jim Secor, Mark Honeyman, Dennis Shannon), ISU weed scientists Bob Hartzler and Matt Liebman, Nematologist Greg Tylka, the diagnostic labs. in Agronomy, Horticulture, and the Grain Quality Initiative, and local Extension crops specialist, Mark Carlton, has enhanced the impact of this project. The Organic Crop Improvement Association (OCIA) and Heartland Organic Marketing Cooperative have also been involved as consultants and participants in dissemination of information gathered from this research. We gratefully acknowledge the help of the Howard Rotavator ® Company in providing equipment for this research.

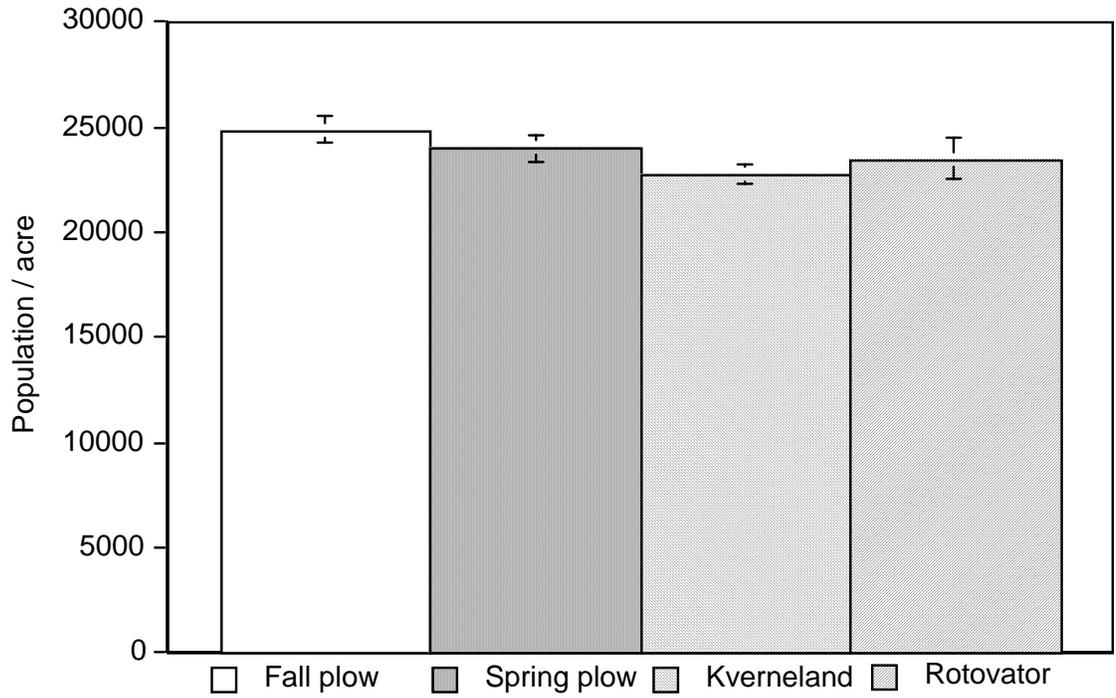


Figure 1. Corn population, 7/17/01, McNay Research Farm.

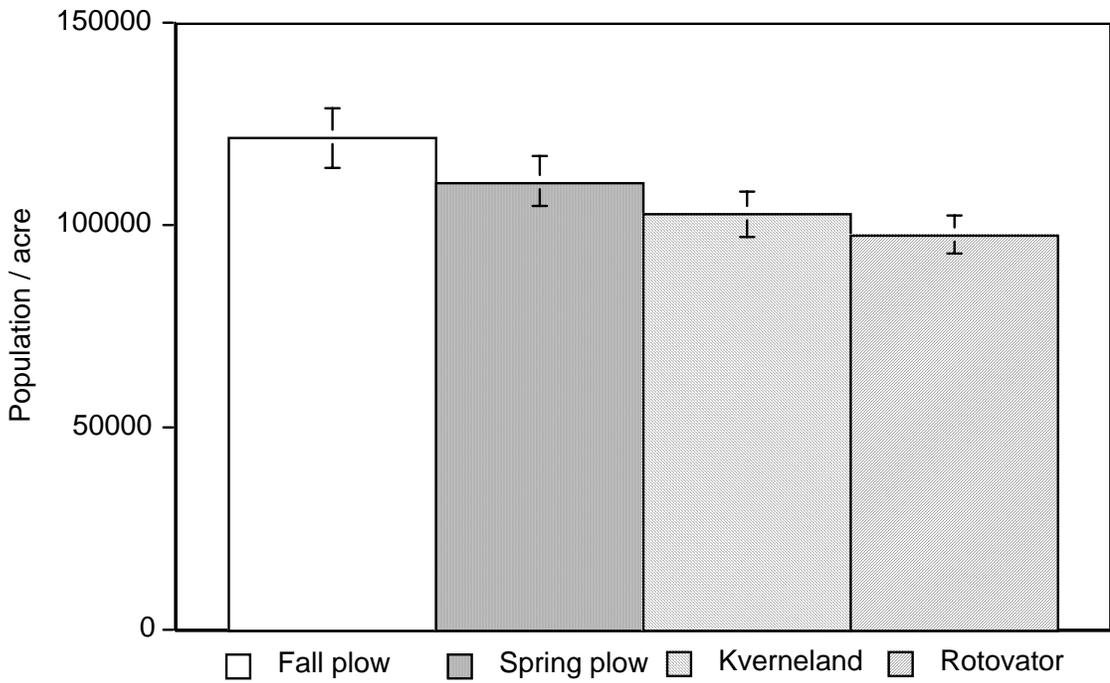


Figure 2. Soybean population, 7/17/01, McNay Research Farm.

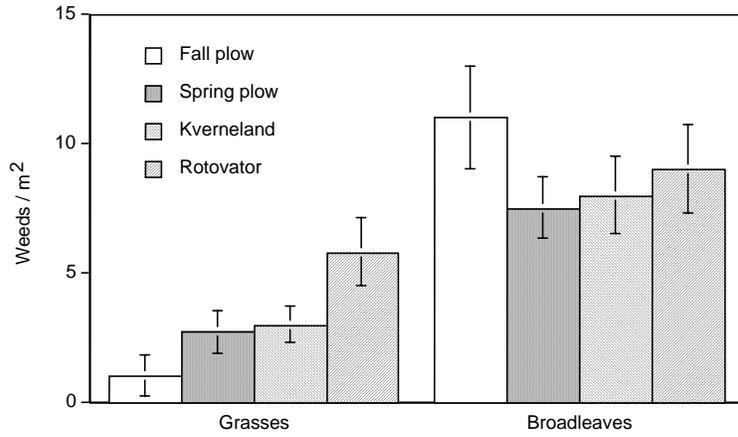


Figure 3. Corn weed population, 7/17/01, McNay Research Farm.

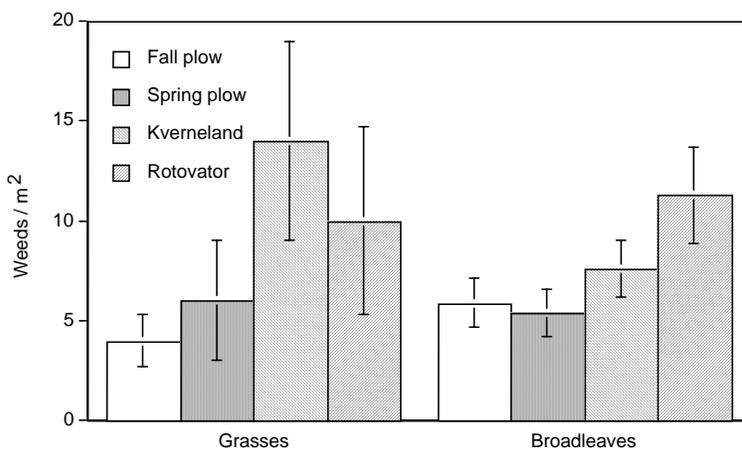


Figure 4. Soybean weed population, 7/17/01, McNay Research Farm.

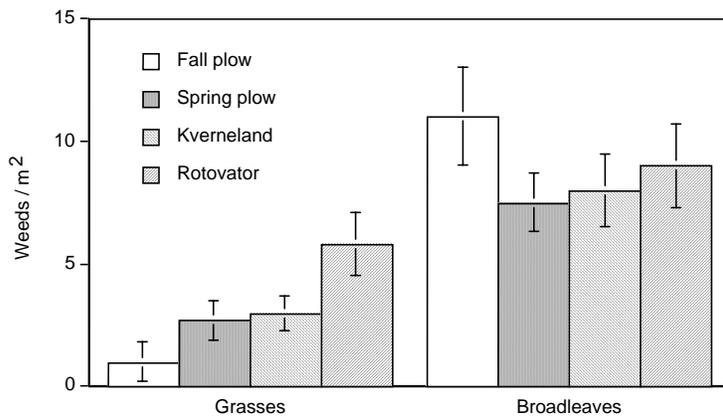


Figure 5. Soybean weed population, 9/24/01, McNay Research Farm.

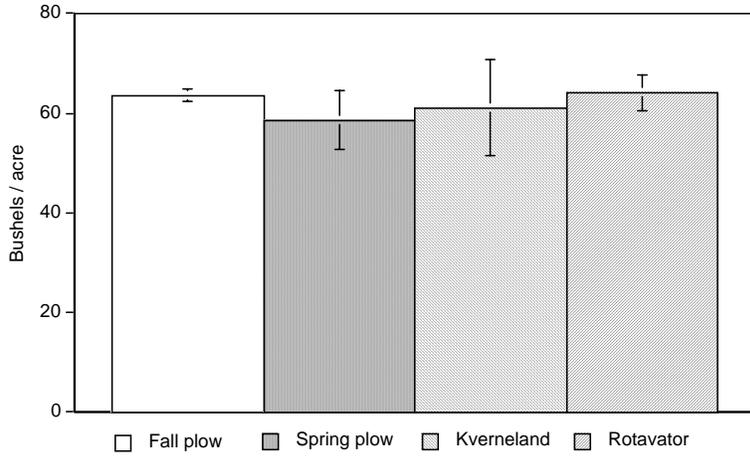


Figure 6. Oat yields, McNay Research Farm, 2001.

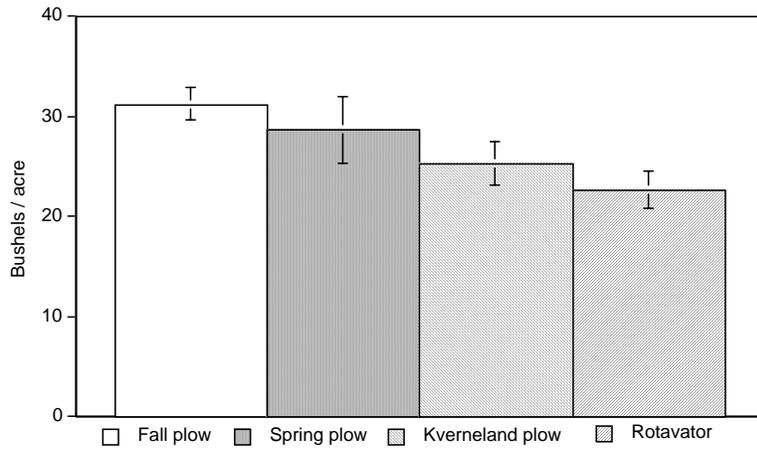


Figure 7. Soybean yields, McNay Research Farm, 2001.

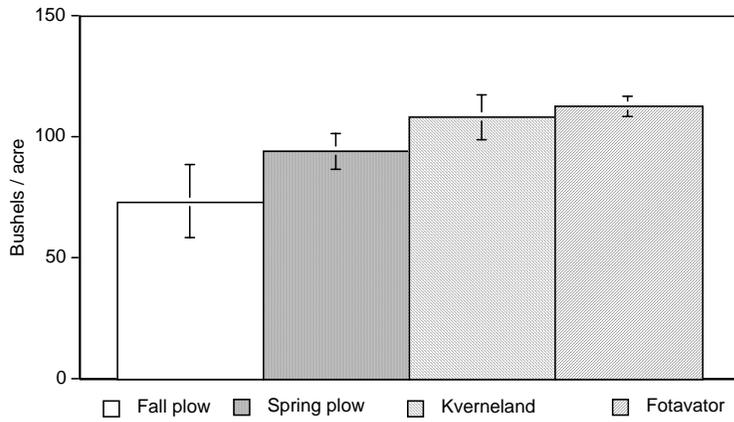


Figure 8. Corn yields, McNay Research Farm, 2001.

Figure 9. Effect of propane flame burning on weed populations in soybean, McNay, 2001.

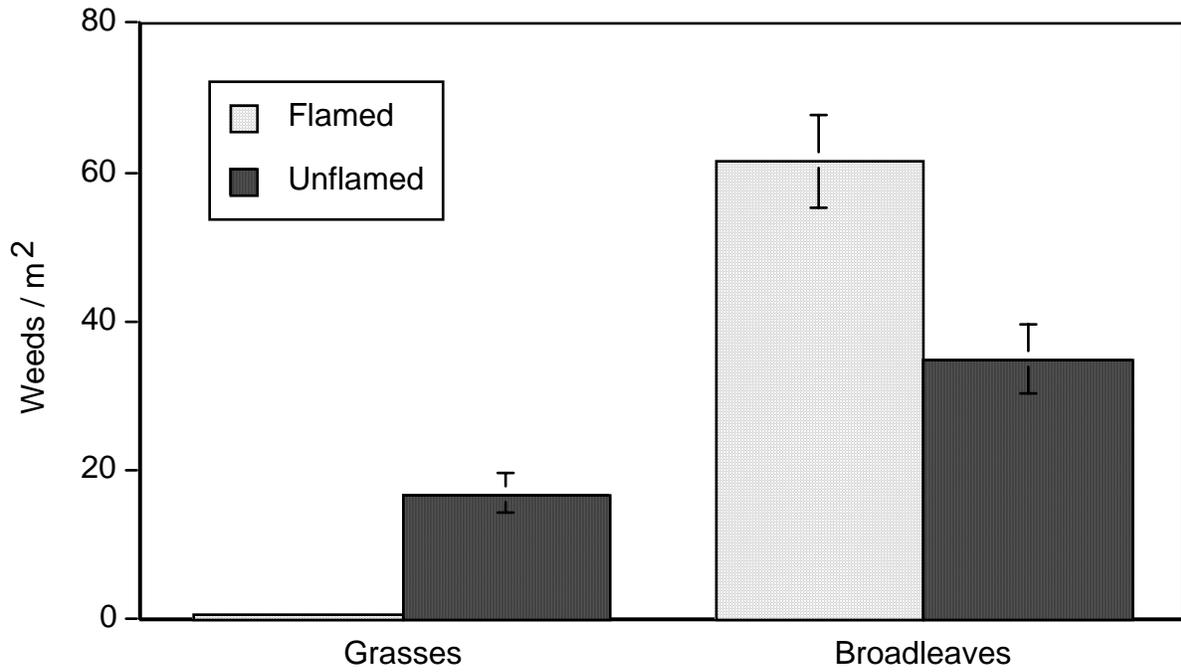


Figure 10. Corn borer damage, McNay, 2001.

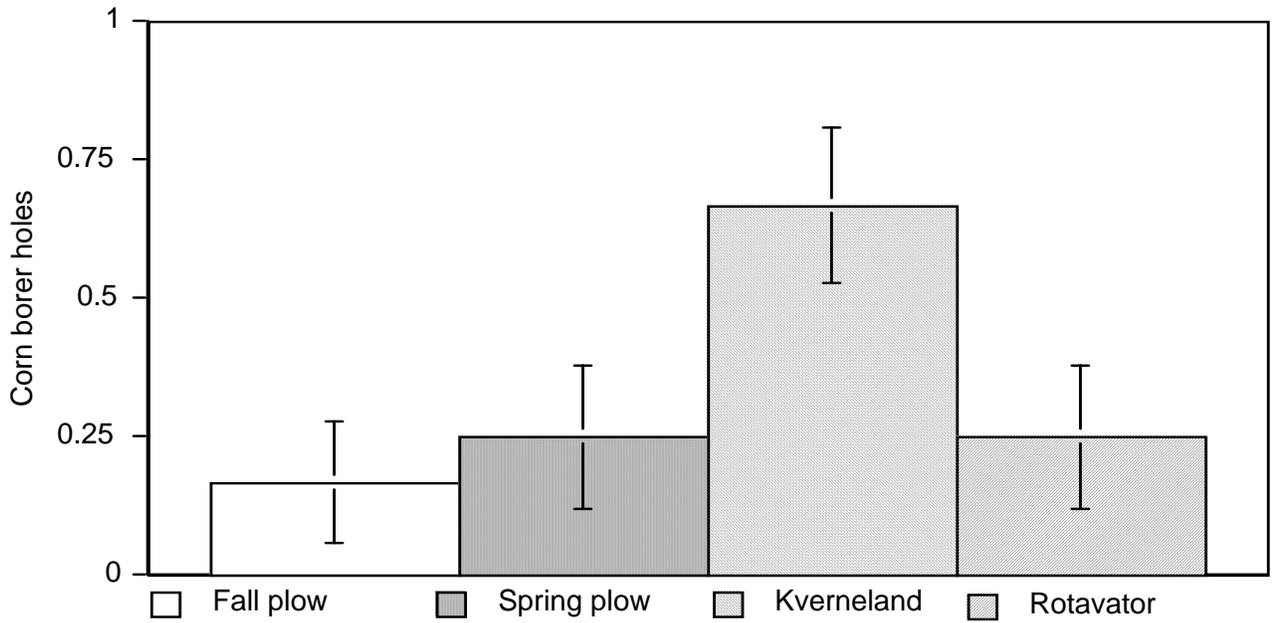


Figure 11. Bean leaf beetle populations, McNay, 2001.

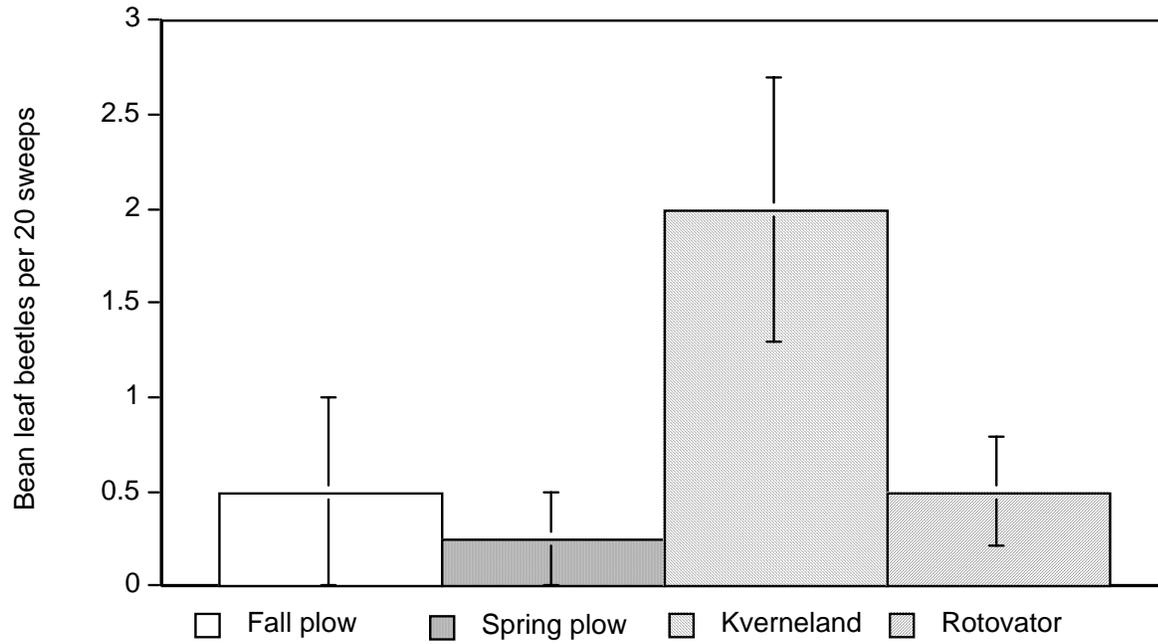


Figure 12. Soybean staining damage, McNay, 2001.

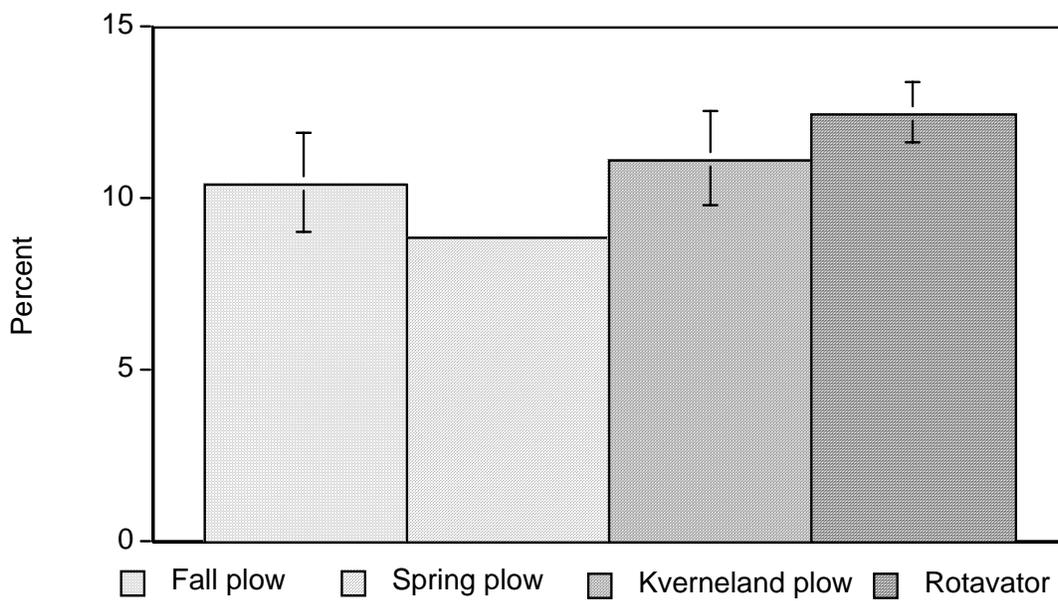


Figure 13. Corn grain quality, McNay, 2001

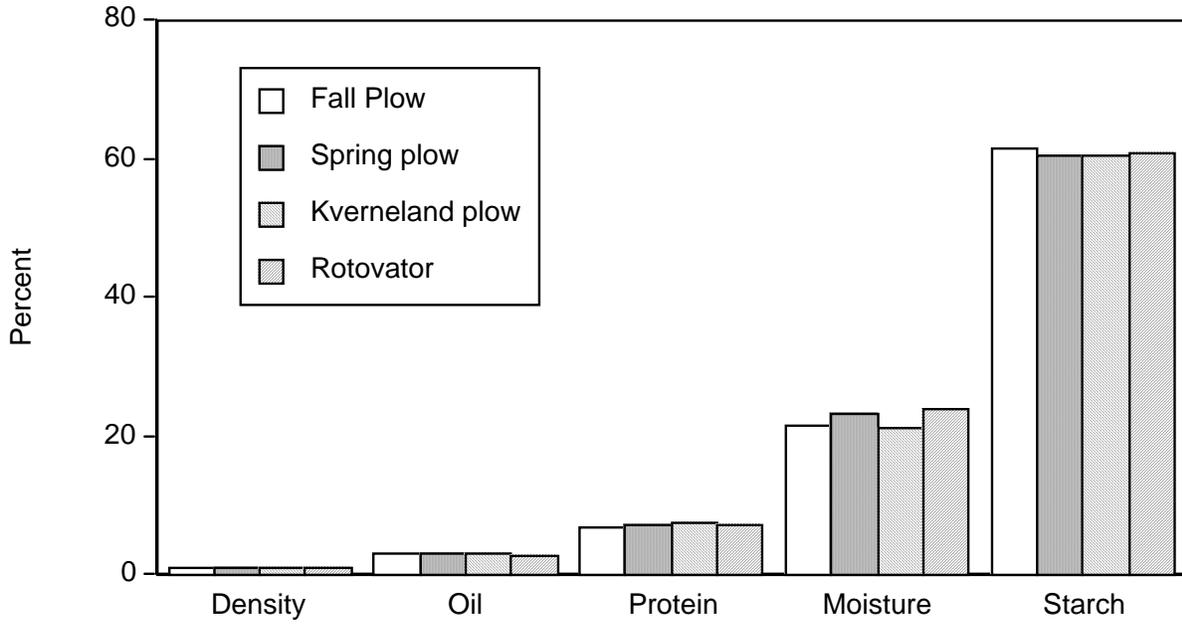
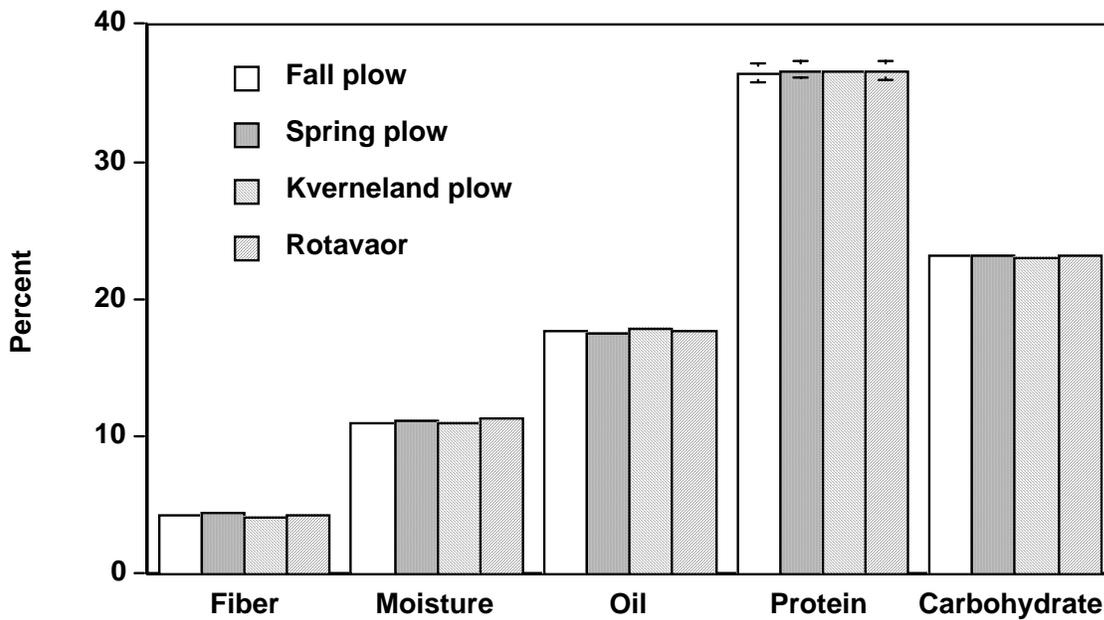


Figure 14. Soybean grain quality, McNay, 2001.



ACKNOWLEDGEMENTS

We gratefully acknowledge the help of Heather Friedrich, Noreen Wantate, Andrea McKern, Sergei Sans Tercel, Gustavo Soares, and Jenny Petersen; the Howard Rotavator ® Company and the ISU R & D farm staff (Jim Secor, Mark Honeyman, Dennis Shannon). The Clinton and Ottumwa NRCS office participated in the on-farm trial, approving our conservation plans once CRP land was tilled. We also involved staff at the USDA National Soil Tilth Lab. in soil analysis; Doug Karlen in fertilization recommendations; Mark Carlton, crop specialist; Jim Boes of Heartland Organic Marketing Cooperative in market information for organic soybeans; and the Iowa State University diagnostic laboratories in Agronomy, Horticulture, and the Grain Quality Initiative.

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