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Potential economic, environmental benefits of narrow strip intercropping

Richard M. Cruse
Iowa State University, rmc@iastate.edu

Douglas Karlen
United States Department of Agriculture

Kenneth J. Moore
Iowa State University, kjmoore@iastate.edu

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Potential economic, environmental benefits of narrow strip intercropping

Abstract
Since its establishment in 1989, the Cropping Systems interdisciplinary research issue team has worked to develop a cropping system that is more environmentally sustainable than current cropping approaches but just as favorable economically. The team's work to date has focused on the strip intercropping concept.

Keywords
Agronomy, Cover crops, double crops, strip cropping

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences
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Background
Since its establishment in 1989, the Cropping Systems interdisciplinary research issue team has worked to develop a cropping system that is more environmentally sustainable than current cropping approaches but just as favorable economically. The team's work to date has focused on the strip intercropping concept.

In strip intercropping, three or more crops—typically corn, soybeans, and a small grain such as oats or wheat interseeded with a legume such as alfalfa or berseem clover (see photo, p. 17)—are grown in contiguous narrow strips of four to six rows each within the same field. Each crop strip is rotated annually (see Table 1). Strips must be equal in width to accommodate this rotation scheme, and farmers must use a strip width compatible with their equipment. Potential advantages of this practice include higher crop yields—due to extra sunlight that taller crops receive on their borders; the "rotation effect" (crops in the system rotate their respective positions in the strip each year); reduced pest problems due to this rotation; reduced reliance on energy-intensive farming inputs; and improved soil erosion control.

Table 1. Rotation and relative position of crops in the narrow strip system.

<table>
<thead>
<tr>
<th>Year</th>
<th>Strip 1</th>
<th>Strip 2</th>
<th>Strip 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>corn</td>
<td>soybeans</td>
<td>small grain/legume</td>
</tr>
<tr>
<td>Year 2</td>
<td>soybeans</td>
<td>small grain/legume</td>
<td>corn</td>
</tr>
<tr>
<td>Year 3</td>
<td>small grain/legume</td>
<td>corn</td>
<td>soybeans</td>
</tr>
</tbody>
</table>

Over the past five years, team members also studied insect and disease pest movement between strips, proper management of the system, its impact on wildlife, and microclimate changes in the crop canopy. What makes the approach a true system are the myriad interactions among these and other variables, such as tillage type, economics, water use, conserva-
tion, energy, and other factors, most of which differ from characteristics of traditional crop fields. By studying these variables in numerous fields, the team has accumulated many "field years" of data, and it has arrived at the following general conclusions:

- The strip intercropping system has greater production potential than do traditional systems.
- The labor requirement is no greater than that for traditional systems, but strong motivation and management skills are important to success.
- Corn rootworm management may require more attention than it does in large fields with similar crop rotations (because the corn strip is adjacent to the previous year's corn strip, allowing overwintering rootworms to burrow "next door").
- While plant disease potential depends on weather, it has had minimal effect on crop yield. Microclimate variations are greater than in traditional large fields; they help to explain the beneficial effects of strip borders on crop yields.
- Focus groups of farmers have indicated that this system warrants additional research.

Studies and findings

Insect populations (Tollefson and Boeve, ISU Entomology): The impact of five cover-crop treatments on corn rootworm adult emergence and larval feeding was investigated at one location (Alta Vista) during 1992. Cover-crop treatments planted in the 1991 oat strips were (1) 'Bigbee' berseem clover, interseeded with 'Don' oats in early April, (2) hairy vetch interseeded with 'Don' oats in August, (3) Tibbee' crimson clover interseeded with 'Don' oats in August, (4) 'Bigbee' berseem clover seeded in August, and (5) oat stubble. Adult corn rootworm emergence traps and corn root ratings were used to determine differences in female oviposition (egg-laying) between cover-crop treatments. No differences were found in adult emergence or average root ratings. Rootworm damage on the row adjacent to last year's corn strip was probably due to larval migration between strips rather than egg laying into the oat strips.

Weed management (Owen, ISU Agronomy): Weather during the 1992 cropping season varied dramatically. May, June, and August were extremely dry, while July had record rainfall. This factor play a significant role in the later-season weed growth and crop/weed interaction. In fact, the major influence on the weed populations during 1992 was the rainfall pattern. Given that the study has now encompassed several rotational cycles, differences between primary factors such as tillage, crop, and herbicide application technique have lessened. Weed pressures seemed to move toward equilibrium, where the influence of crop and tillage seemed less marked than when the experiments were initiated. As a result, weed control strategies—broadcast, banding, or no herbicide application—were not as dramatic in 1992 as in earlier growing seasons.
Wildlife use (Best, ISU Animal Ecology): Sustainable agriculture initiatives such as strip intercropping hold promise for improving habitat conditions for wildlife in agroecosystems. A study initiated on a farm near New Hampton observed birds and small mammal populations within the full-scale strip intercropping system in place there. Birds were observed from tower blinds and censused along transects. Thirty-one bird species were observed, with vesper sparrows and brown-headed cowbirds most abundant. Soybean strips were preferred for use by birds. Nineteen vesper sparrow nests were found in strip intercropping systems; one nest successfully fledged young. The remaining nests were destroyed by cultivation activities (53%), predators (26%), desertion (11%), and brown-headed cowbird parasitism (5%). Nesting birds preferred corn strips. Small mammal use of strip intercropping systems was evaluated by use of live-traps. Three species of small mammals were captured; deer mice were most abundant. Small mammals preferred oat strips in June before oat harvest and soybean strips in August after oat harvest.

Disease potential (Martinson, ISU Plant Pathology): Foliar disease spread is a potential problem with strip intercropping because the residue of the previous year’s crop remains in close proximity to the new crop each year. Foliar diseases have developed in oats, corn, and soybeans planted in the strip intercropping design at the McNay Research Center in 1992 and 1993 and in corn and soybeans planted at the ISU Agronomy and Agricultural Engineering Research Center in 1992. The pattern of disease development was from the edge of the strip that was contiguous with the land planted to the same crop the prior year (see Table 1). A section of each strip was sprayed with a foliar fungicide at about 10-day to two-week intervals, depending on the rate of plant growth, frequency of prior rains, and apparent disease pressure. The purpose was not to have completely disease-free plots, but to prevent the development of an epidemic that could result in yield loss. Soybean yields were measured in 1992 and 1993; oat and corn yields were determined in 1992, but in 1993, the wet soils resulted in very poor and erratic growth of both corn and oats.

Microclimate (Jurik, ISU Botany): The microclimate of narrow strip intercropping systems that include oats, soybeans, and corn in four-row or five-row strips was studied in 1992 on a farm near Boone (in an east-west row orientation) and at the ISU McNay Research Center near Chariton (in a north-south row orientation). Little spatial variation occurred in soil and air temperatures and air humidity as a function of row position in the strip. Wind speed in the upper-middle canopy typically was highest on the outer row of each strip, but this pattern depended greatly on wind direction. The amount of light received by the upper-middle canopy of oats was greatest on the edge of the strips. For both row orientations, light received by soybeans was highest for soybeans furthest from corn and lowest for soybeans closest to corn. Light received by corn was slightly higher for the two outer rows of the corn strip than for the inner rows in north-south strips. In east-west strips, the southernmost row of corn, next to soybeans, received the most light, while the northernmost row received less.

Brown spot (Septoria blight) was the prevalent fungal disease on soybean each year. Yield increases varied from two bushels per acre in 1992 to seven bushels per acre in 1993. Bacterial blight developed also, but it cannot be controlled by fungicides. Gray leaf spot and Northern corn leaf blight were the most prevalent diseases of corn in 1992 and were present also in 1993, but in 1993, common rust was devastating. Common rust does not originate from crop residue; rather, it is blown in each year. Yields of corn in strips were increased by seven to nine bushels per acre in 1992 following fungicide applications for control of the epidemics.

Helminthosporium leaf blotch was the major problem on oats, with some Septoria leafblight as well. No yield losses were measurable in oats because of disease.

Nitrogen and rotation benefits to corn from interseeded legumes in oats (Anderson, ISU Agronomy): Legumes as previous crops to corn contribute both a residual nitrogen (N)
effect an a non-N effect called a rotation effect. During the first year of the system (1992), oats with ten interseeded legumes and two oat controls per replication were grown. During the second year, each oat-legume main plot was planted to corn with four rates of N fertilizer: 0, 50,100, and 200 pounds per acre, applied to each previous legume plot. Legume fertilizer replacement values were calculated from corn grain yield and rate of N. Alfalfa had a value of 92 pounds per acre of N, followed by red clover, berseem, vetch, and faba bean. The oat-legume treatments were planted again for a 1994 corn evaluation. Data were collected from the corn plots to evaluate residual N effects and non-N effects of the legumes on grain yield of corn. Once the most effective legume for enhancing corn yield is determined, it will eventually be tested with strip intercropping to determine its effect on corn response in this system.

Recent focus
Research on most of the above-listed aspects of the system was completed by the end of 1993. A new focus this past year involved finding legumes that are compatible overall with the system. This area of study has led to collaborations with the Animal Management team (see p. 8) to study the viability of oats and berseem clover as a green chop feed supplement in grazing situations. One such scenario will involve managed grazing of the strips after corn and soybean harvest.

The first strip intercropping approach to gain widespread acceptance used only corn and soybeans. This system elevated corn yields but depressed soybean yields. Adding the small grain/legume strip still allows for high corn yields while improving the soybean response. This configuration also increases small grain yield over that occurring in traditional fields. Economic analyses indicate that if output can be improved for the small grain strips, this system can move from being marginally viable economically to offering an economic return superior to that of conventional cropping systems. Inclusion of a legume or a second crop in the small grain strips may increase the output and economic return.

A conventional small grain/legume combination in Iowa includes oats interseeded with alfalfa or mammoth red clover. An oat/hairy vetch mixture seeded after oat harvest is also a common practice. In some cases, hairy vetch depletes soil moisture necessary for subsequent crop production. Also, chemical or mechanical elimination of alfalfa in the fall, or prior to germination of the succeeding crop in the spring, is a major management consideration.

In the past two years, the team has identified berseem clover as a promising legume for interseeding with the small grain. In terms of the criteria used in assessing candidates for the legume component of the strip system, the legume should resist insects and disease, suppress weeds, fix nitrogen, grow well during hot, dry summers, lack winter hardiness (therefore reducing interference with corn planted in the strip the following spring), and ideally, produce seed to save the expense of purchasing it each year. Berseem is a very viable candidate. Its regrowth following small grain harvest compares favorably with alfalfa, as does its tolerance to drought and moisture stress; it is successful on a wide variety of soils; it has good potential as a forage legume, particularly if it is chopped to feed livestock; it

In the past two years, the team has identified berseem clover as a promising legume for interseeding with the small grain. This berseem was interseeded with oats, which were then harvested, after which the berseem continues to grow. It can be grazed, harvested for hay, or left as a cover crop.
is a true annual; and it grows rapidly. In some conditions, if it is allowed to grow until oat harvest, it can interfere with oat grain harvest. Selection of a short season oat variety that grows tall may help to avoid this interference.

In the recent collaboration with the Animal Management team and Practical Farmers of Iowa members, the oat/legume strip was green chopped and fed to livestock instead of harvested for grain. (In green chopping, green forage is cut with a field chopper and hauled to lots or barns in lieu of pasturing.) This approach increases economic viability significantly if manure is recycled onto the strips.

The strip intercropping system also leaves crop residue on the ground over the winter, which aids in erosion control. While ridge tillage is helpful for controlling weeds and providing precise marking at the start of each cropping system, other tillage approaches have also been used successfully with the system.

**Future directions**

As the work begun five years ago matures, the team is well positioned to further explore systems for integrating crop with livestock production. Such systems are especially suitable for less productive, "marginal" land with higher erosion potential. Such lands are suitable environmentally and economically for pasturing ruminant livestock for milk or meat production, while grain produced on more suitable land can be used to finish cattle on the farm, with the excess sold for cash. Development of integrated crop-livestock systems offers many opportunities and advantages for Iowa:

- **Production of ruminant livestock using perennial forage crops on marginal land:** Input costs for producing row crops have continued to increase, while grain prices have remained steady or declined. Consequently, profit margins for producing continuous row crops continue to decline as well. The impact of these trends is especially acute on marginal land, which is inherently less productive and unsuitable to large-scale farming. Integrating crops and livestock on such land allows for many production cost reductions; on-farm grain and forage production is used at the

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**Potential advantages of strip intercropping include higher crop yields—due to extra sunlight that taller crops receive on their borders; the "rotation effect" (crops in the system rotate their respective positions in the strip each year); reduced pest problems due to this rotation; reduced reliance on energy-intensive farming inputs; and improved soil erosion control.**
source, reducing transportation and storage costs. Crop rotation opportunities increase, allowing for low- or no-cost pest management options. Crop rotation effects can increase yields, and greater crop rotation opportunities are often more conserving of soil than continuous row cropping. Finally, integrating crops with livestock utilizes labor more effectively.

- **Integrated crop-livestock systems are environmentally sound.** Agriculture is a major nonpoint-source contributor to ground and surface water pollution. The amount of potential contaminants from integrated crop-livestock systems is reduced because they have lower input requirements and erosion potential. Nutrients are cycled within the system, reducing the need for chemical fertilizers. Manure becomes a resource rather than a waste product in diversified farming systems, and it does not become concentrated in any one place. Crop rotation and buffer strips reduce the need for pesticide and fertilizer. Perennial forage grasses and legumes grown for pasture have much less soil erosion potential than row crops, which are currently grown on marginal land.

- **Integrated crop-livestock systems enhance economic development in rural communities.** Diversified farming is more suitable to smaller scale operations than extensive row crop production. Diversifying farms creates opportunities beyond simple expansion of land holdings. Livestock adds value to a farmer's grain crop, thereby increasing his share of the return from grain production. As a result, a community of diversified farms should be able to support a larger farm population than one in which the agriculture is highly industrialized. More farmers on the landscape means more jobs in town and improved cultural and educational opportunities.

**Objectives:** Because so many management options exist for both crop and livestock production, a wide range in profitability also likely exists with different combinations of crop and livestock systems. Identifying the most efficient, productive, and complementary set of crop and livestock systems offers advantages from both economic and environmental perspectives.

Thus, the goal of this research is to evaluate the productivity and sustainability of several cropping and livestock management systems for beef cattle production on marginal land. Specific objectives are to (1) evaluate the economics and environmental impact of conventional and conservation cropping systems on marginal soils, (2) evaluate the economics and environmental impact of several beef cattle production systems, and (3) evaluate the complementary aspects of integrated crop-livestock production systems.

**Approach:** Cropping and beef production systems will be evaluated simultaneously at a single location. The location will represent land of marginal production potential. The cropping systems to be evaluated include continuous corn, corn-soybean rotation, corn-soybean-small grain rotation, and corn-soybean-perennial forage rotation. Within each of these systems, different tillage methods and use of buffer strips will also be evaluated. The beef production systems will focus on feeder cattle and will include various combinations of pasture and feedlot feeding programs, ranging from moving calves directly to the feedlot to finishing cattle on pasture. The complementary aspects of these systems to be evaluated include nutrient cycling, value-added aspects of feeding grain produced within the system, and economic advantages of enterprise diversification. Potential advantageous outcomes of such research would include improved soil and water conservation, reduced input costs, greater management flexibility, improved beef production on pasture, and beneficial crop rotation effects.

For more information contact R. M. Cruse, Agronomy, Iowa State University, Ames, Iowa 50011, (515)294-7850.