DIVERSITY: A KEY ELEMENT OF SUSTAINABLE AGRICULTURAL SYSTEMS

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Introduction

Over the last five decades, Iowa's agricultural landscape has become markedly less diverse in both crop and non-crop vegetation. In 1950, corn and soybean were planted on 27% and 6%, respectively, of Iowa's farmland, but by 1994, corn and soybean occupied 39% and 27% of the state's farmland (Kanwar and Klonglan, 1998). During this same period the percentage of Iowa farmland planted with oat fell from 19 to 2%; hay acreage dropped from 11 to 5% (Kanwar and Klonglan, 1998). This type of reduction in crop diversity across the landscape is related to low diversity in individual fields over time. More than 90% of the >21 million acres planted with corn and soybean in Iowa in 1991 contained only those two crops in 1989 and 1990 (USDA-ERS, 1992). Intensification of crop production in Iowa through drainage and field enlargement has resulted in a reduction of wetland vegetation and tree cover along streams and former field borders (Schultz et al., 1997).

The gains in crop production per acre and farm labor efficiency made in Iowa during the last half of the 20th century are envied by much of the rest of the world. However, these productivity increases have been accompanied by substantial environmental costs, including water pollution, excessive soil erosion, and loss of wildlife habitat. Increases in crop yields and labor efficiency have also failed to provide to protect many farmers from the squeeze of rising production costs and low commodity prices (Smith, 1992). Iowa farmers retained about 40% of their gross farm income in the early 1950s, but kept only about 20% in the 1990s (Duffy, 1998).

It is my contention that increases in biodiversity can improve the quality of Iowa's natural environment and the health of its farms, though the necessary changes in cropping practices and landscape management will not be easy to make. History indicates that new crops and landscape management practices can be developed and introduced successfully if there are appropriate technical innovations, economic initiatives, and partnerships between farmers, university research and extension personnel, and planning and policy agencies. Soybean was a minor crop in the U.S. until grower organizations, USDA and university researchers, and private seed breeding and processing companies initiated coordinated efforts in the 1920s to develop better varieties, effective pest management practices, and new processing facilities and marketing opportunities (Lockeretz, 1988). Similar coordinated approaches have fostered increases in crop diversity in Saskatchewan. In 1995, wheat and summer fallow occupied 34% and 26%, respectively, of Saskatchewan's cultivated farmland, but the remainder was planted with a range of other crops, including canola, barley, oat, hay, field pea, lentil, chickpea, flax, and mustard seed (SAF, 1996a & 1996b). In contrast, across the border in Montana, where diversification efforts have not been pursued, more than 90% of land planted with wheat is grown in rotation with only wheat, barley, or fallow (USDA-ERS, 1992). Cooperative efforts involving farmers, researchers, environmental organizations, and government agency personnel can also provide good opportunities for restoring native vegetation to agricultural landscapes. In north central Iowa, farmers, ISU researchers, and other members of the public sector have worked together and greatly increased tree, shrub, and prairie grass cover in the Bear Creek watershed, thereby reducing water pollution and soil erosion, and increasing bird populations (Schultz et al., 1997).

Priority Areas for Research and Innovation

I believe there are three important issues related to biodiversity that will benefit from more research and innovation by scientists and farmers in Iowa.

Longer crop rotations

The yield benefits of crop rotation have been well established in Iowa and elsewhere. For corn and soybean, rotation yield advantages are typically on the order of 10-15% (Bullock, 1992; Karlen et al., 1994). When forage legumes are included in rotations, yields of succeeding non-legume crops can benefit from nitrogen contributions (Fox and Piekielek, 1988). However, yield advantages from crop rotation are commonly observed even at high levels of fertilizer application (Heichel and Barnes, 1984; Voss and Schrader, 1984). Non-N benefits of crop rotation have been attributed to improvements in soil microbiological and biochemical conditions and reductions in pathogen populations (Cook, 1990; Bullock, 1992; Karlen et al., 1994). Rotation benefits can be particularly marked under stressful growing conditions, including years with cool spring temperatures and mid-summer droughts (Porter et al., 1997b).

Yield benefits of crop rotation for corn, soybean, and wheat are greater for three-year rotations than two-year rotations (Cook, 1990; Crookston et al. 1991; Porter et al., 1997a). That is, the longer the interval between when a crop is grown and when it reappears on the same field, the greater the yield. Thus a key objective for Iowa agriculture is to move beyond two-year corn-soybean rotations into sequences that contain three or more crops. This will be particularly important as insect pests such as western corn rootworm widen their host range to include both corn and soybean (Grossman, 1998). Winter annual crops, such as winter wheat, appear to provide important weed control benefits when grown in rotation with corn and soybean (Schreiber, 1992). Strategies to improve winter wheat survival and marketing could provide Iowa farmers with better opportunities to produce and sell a crop whose world market demand is projected to increase 40% in the next 20 years. Research into the production, protection, processing, and marketing of a wide range of alternative crops should be a priority in Iowa.

Improvements in intercropping and cover cropping strategies

Intercropping and cover cropping are important strategies for adding organic matter, fixing atmospheric nitrogen, reducing soil erosion, and preventing nutrient leaching. A range of intercropping options are compatible with fully mechanized farming. When herbicides are band-applied, forage species such as annual ryegrass and red clover can be sown between rows of corn at the final cultivation (Scott et al., 1987; Wall et al., 1991). The development of glyphosate-resistant corn and alfalfa varieties may facilitate corn-alfalfa intercropping. Oat can be sown into soybean in mid-August in Iowa to increase residue cover without affecting soybean yield (Johnson et al., 1998). More research is needed to determine the impacts of interseeding other species into soybean. Oat, barley, and wheat are easily grown with forage legumes (Hesterman et al, 1992; Stute and Posner, 1993), but more research is needed to determine the best choice of species and cultivars for different crop production regions in Iowa. Rye and other winter cover crops can provide a valuable means of increasing residue cover (Johnson et al., 1998), suppressing weeds (Liebl et al., 1992), and retaining nutrients (Shipley et al., 1992; Ditsch et al., 1993), but more needs to be learned about their management. For example, rye used as a cover crop was found to reduce the yield of a succeeding corn crop, whereas an oat cover crop did not have this effect (Johnson et el., 1998).

Impacts of diversifying landscapes

As previously mentioned, farmers have restored vegetation in Iowa's Bear Creek watershed and researchers have documented the attendant environmental benefits. Riparian vegetation acts as a filter strip to greatly reduce the movement of herbicides, fertilizers, and soil from cropland into surface water (Schultz et al., 1997). Recent interest in "farmscaping" by growers in northern California has focused attention on how non-crop vegetation surrounding farm fields affects wildlife and beneficial insect populations (King and Olkowki, 1991). On-farm measurements in the Sacramento Valley indicate that establishment of trees and perennial herbs and grasses has increased bird density and species diversity, and in certain cases raised populations of beneficial insects that attack crop pests. Recent research in Britain has shown that aphid pests of wheat can be reduced by planting narrow corridors of perennial grasses that provide habitat for predatory ground beetles (Wratten and Van Emden, 1995). Although it can not be assumed that agricultural production will necessarily benefit from diversifying landscapes with non-crop species, there is clearly much to learn about this approach. A review of the ecological services and benefits provided by diversified agricultural landscapes is currently being prepared by the Council for Agricultural Science and Technology and the Ecological Society of America.

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