

Recognizing Challenges to Iowa's Annual Cropping Systems

Iowa's soybean and corn cropping systems are among the most productive in the world. Approximately 23.5 million acres of soybean and corn are harvested annually generating \$20 billion of economic revenue for the state. New tools, technologies, and the use of science-based best management practices allow Iowa farmers to increasingly feed more people with a shrinking acreage base. However, the technologies that enable farmers to accomplish this admirable task are failing in some areas. Failure of these technologies limits yield and increases input costs putting the farmer at risk of not being able to compete for land and other resources.

CHALLENGES TO IOWA'S CROPPING SYSTEMS

Current cropping systems utilize either an alternate-year rotation of soybean followed by corn (soybean-corn), one year of soybean followed by two years of corn (soybean-corn-corn), or continuous corn. These rotational sequences: (i) maximize farmer income; (ii) promote higher yields for one or both crops; (iii) increase residue cover of the soil resulting in increased organic matter and reduced soil erosion thus protecting air and water quality; and (iv) reduce disease, insect, and nematode pressure.

Tillage is a traditional management practice that is widely used in Iowa's highly productive cropping systems. It manages residue left by the harvest of previous crops, controls weeds that



compete with the current crop, and incorporates amendments such as fertilizers and manure. However, it does little to improve soil health, water infiltration rate, water quality, and long-term soil structure.

In contrast, no-till production systems improve soil and water quality by increasing organic matter; improving water infiltration rate (10); conserving soil moisture; and decrease fuel, equipment and labor costs (6). Furthermore, studies conducted by Iowa State University showed yields from no-till planted soybeans were not significantly different from soybean grown in fields in which tillage was used (*See Influence of Tillage on Soybean Production in Iowa*). Approximately 88 percent of the estimated 14.6 million acres of corn planted in Iowa in 2012 were planted with one or more tillage passes prior to planting. Just 12 percent were planted using less intensive tillage practices including no-till. In contrast, approximately 60 percent of Iowa's soybean

acres are planted using no-till according to the most recent USDA estimate (16).

Revenue generated by soybean and corn sales, government subsidies, and land tenancy limitations generally determine which crop rotational sequence is used by farmers. Cropping systems that include alternative crops such as alfalfa or small grains are rarely included in the rotation. However, research suggests that cropping systems that include alternative crops can be economically viable (11) and could be used to diversify current production programs.

The environmental costs of the state's current cropping systems are under increasing scrutiny. Many argue that the continuous planting of the states two primary crops in continuous corn or in soybean-corn or soybean-corn-corn rotations is not sustainable and that only planting two crop species has already put farmers and the technologies on which they rely at risk.

Evolving weed, insect, and pathogen resistance are very serious threats to profitable soybean and corn production in the United States.

Recent reports by university researchers reveal that key insect resistance traits in corn are losing efficacy against the corn rootworm in multiple areas of the Corn Belt. Gassmann and coworkers (4) were first to report that populations of western corn rootworm in Iowa have evolved resistance to the crystalline Bt toxin Cry3Bb1 in corn. The Cry3Bb1 toxin is a trait sold in select YieldGard®, Genuity®, and SmartStax® branded corn hybrids. The primary cause for the failure of this technology appears to be an over-reliance on the Cry3Bb1 technology in continuous corn rotations. Experts agree that continued reliance on this gene may threaten the efficacy of similar genes and genes with which Cry3Bb1 is stacked.

Although the prophylactic use of fungicides on soybean and corn is a relatively new management practice, strobilurin fungicide use on soybean is already threatened by the

emergence of a resistant biotype of *Cercospora sojina*, the causal agent of frogeye leaf spot. The presence of this resistant biotype has been confirmed in Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee (2). Strobilurin fungicide active ingredients currently registered on soybean include azoxystrobin (found in Quadris®, Quilt®, and Quilt Xcel®), fluoxastrobin (Evito®), pyraclostrobin (Headline®), and trifloxystrobin (Stratego®, Stratego YLD®). It has been postulated that an overreliance on strobilurin fungicides for foliar disease control in soybean caused the resistant biotypes of the pathogen that were already present in the fields to become dominant. Spores of the resistant biotype will move from affected fields into fields in surrounding areas causing future problems in increasingly larger geographies. It is not uncommon for pathogenic fungi to quickly evolve resistance to the strobilurin fungicides (1).

Herbicides and tillage were keystones of high-yield grain production in United States agriculture for many years. The nearly instantaneous adoption of glyphosate as a weed management option in several crops resulted in less herbicide applied for weed control and it promoted conservation tillage practices such as no-till. The herbicide's relatively low cost and broad-spectrum weed control made it an easy choice to improve management efficiencies in large-scale grain production systems. Glyphosate has been nearly the only herbicide many farmers have used in their soybean and corn production programs since Roundup Ready® soybeans were introduced in 1996.

Today, weed resistance to herbicides is one of the most serious threats to profitable soybean and corn production in the United States. The emergence in Iowa of populations of waterhemp,

giant ragweed and horseweed resistant to glyphosate was not unexpected. There are currently 22 different biotypes of weeds resistant to at least one herbicide in Iowa (17). Like the strobilurin fungicides, an overreliance on the glyphosate chemistry is one, but not the sole, reason for the emergence of glyphosate resistant weed populations.

The reality and abundance of herbicide resistant weeds has reintroduced complexity and greater expense into weed management programs. Because weed management programs will likely revert to tillage and a greater reliance of multiple herbicides (12) concerns related to the impact of these weed control tactics on environmental quality will likely be elevated.

The approach of the chemical industry to herbicide resistant weeds is to develop crops resistant to 2,4-D, dicamba, and glyphosate. Combining the diverse modes of action may provide farmers with an additional tool for weed management and yield protection. However, many weed scientists believe that without a high level of stewardship the overuse of these herbicides could lead to an escalation in the herbicide resistant weed problem (12). It is plausible that weeds already resistant to glyphosate could also evolve resistance to 2,4-D and dicamba. The evolution of weeds resistant to multiple herbicides, of diverse modes of action, has already occurred in some areas including Iowa (17).



Clearly, a more sustainable and environmentally sensitive solution to weed management is needed.

If herbicide resistant weeds and fungicide resistant pathogens weren't enough, global climate change has resulted in more extreme weather events. Most climatologists predict that instead of a relatively steady cycle of moderate rain and dry periods, farmers will experience more severe droughts punctuated by more severe, high-intensity storms. This variability will add yet another dimension of uncertainty to farmer profitability unless steps are taken to improve the current cropping systems so they are more resilient to environmental shifts of rainfall and temperature.

COVER CROPS

Cover crops have been used globally to reduce soil erosion, improve soil and water quality, and are a likely choice to help improve the resiliency of monoculture-based cropping systems like those of Iowa's soybean- and corn-dominated production system. Soybean produces much less residue than corn and thus leaves more soil exposed to wind and water erosion during fallow periods. Cover crops provide ground cover outside of the normal cropping season thus reducing the risk of soil loss from wind and water erosion following a low residue crop such as soybean, corn harvested for silage, and corn harvested for seed production (9,10).

While cover crops are not widely planted in Iowa, the primary cover crop species planted are oat and winter rye (14).

Fall-seeded oat overwinters poorly in Iowa and provides little protection against spring rainfall. In contrast, winter rye overwinters well in the Corn Belt and has been shown to provide as much as 18 percent more residue at planting in



Cover crops of winter rye (above) reduce soil erosion caused by water and wind.

no-till systems (10) but it may also reduce yield of corn (13).

Research conducted by the United States Department of Agriculture in partnership with Iowa State University proved that the use of cover crops in traditional corn-soybean cropping systems provides clear environmental and soil productivity benefits. The benefits include erosion control, limiting NO_3 -nitrogen leaching (5, 10), weed suppression (15), and increasing soil productivity through increasing soil organic matter and water infiltration rate (10). Soil structure may also be improved through the use of cover crops. Kaspar and Singer (10) postulated that cover crops can improve soil structure directly through formation of pores and aggregates by roots or indirectly through the addition of decomposition of plant shoot and root residues. They further concluded that soil structural changes were highly dependent upon multiple factors including climate, soil type, tillage, cropping system, cover crop species and biomass production.

Cover crops reduce leaching losses of NO_3 because they extend the period of active nitrogen and water uptake to periods of the year when soybean and corn are not actively growing. This dramatically reduces leaching loss of NO_3 by plant uptake, which reduces its concentration in the soil solution, and by taking up water, which reduces the amount of water moving through the soil profile (10). Kaspar and Singer (8) reported a 61 percent reduction in leaching of NO_3 when winter rye was used as a cover crop. They also reported however, that the amount of NO_3 leached from the soil profile can vary widely and is dependent upon the cover crop species used and rainfall.

Cover crops can be overseeded shortly before (7) or planted soon after harvest of the main grain crop in the fall. Vegetative growth that occurs in the fall provides soil cover during winter months that can help capture and retain snow. In the spring, vegetative material, along with crop residue, provide cover to reduce the destructive impacts of rain that falls on unprotected soil.

Dabney (3) reviewed several studies and concluded that cover crops also increase the rate and amount of infiltration from rainfall in conventional and no-till systems. He postulated that the increase in infiltration may happen through several mechanisms: (i) prevention of surface sealing by reducing the direct impact of rainfall on the surface; (ii) an increase in the water storage capacity of the soil created by increased water use by the cover crop; and (iii) an increase in macroporosity caused by the decay of cover crop roots and possibly by an increase in soil fauna.

Cover crops are also reported to contribute to increased soil stability by rendering soil less erodible. Dabney concluded from his review that roots of cover crops, and the fungal hyphae

associated with them bind the soil to make it more resistant to movement by water. However, it appears that the greatest benefits from cover crops, with regard to increasing soil stability, are attributed to the increased amount of residue left on the soil surface from conservation tillage and no-till practices.

Many studies have shown the benefits and limitations of cover crops. However, the primary factor that drives the adoption of any new management practice is its impact on yield of soybean and corn. Kaspar (10) reported that soybean yields were not significantly affected in studies conducted in Iowa where winter rye was used as a cover crop following corn silage harvest. Researchers conducted studies in central Iowa over four years and reported that soybean grain yield following a winter rye cover crop was 53.6 bushels per acre compared with 55.1 bushels per acre without a cover crop (10). From these studies, and many others looking at the use of small grains as a cover crop in Iowa, cover crops are a viable management practice that can be used to reduce soil erosion following a harvested soybean crop, corn harvested for silage, and corn harvested as seed corn.

CONCLUSIONS

The rapid embrace of new technologies such as genetically enhanced crops and global positioning systems has improved operational efficiencies of farming operations of all sizes. These technologies have improved pest control options, reduced pesticide usage, and facilitated the adoption of conservation practices such as no-till. When used wisely they can improve the resilience and sustainability of production agriculture. As stewards of these technologies

their use must be properly managed to sustain the nation's low cost, high-yield production system of food, feed and fuel.

Ultimately, improvements in resilience and sustainability of cropping systems are achieved when decision makers make management decisions that are beneficial both economically and environmentally and increase the long-term efficiency of farming operations. Crop specialists and farmers must become more proficient at early recognition of threats to Iowa's cropping systems and make proactive changes in management practices to ensure long-term use of valuable technologies that increase crop yield and yield stability.

Although change is needed in many areas of crop production, the overwhelming need is to increase the diversity of crops and management practices used throughout the current cropping systems. Greater diversity is needed in the use of insecticide, fungicide, and herbicide use along with the discovery of new chemistries with diverse modes of action. A greater

awareness of science-based best management practices would diversify control tactics for insects, pathogens and weeds and slow the emergence of new populations of pests resistant to control measures. New high-value crops including summer annuals and cover crops are needed to diversify Iowa's monoculture-based soybean and corn cropping systems, reduce soil erosion, improve soil health and water quality, and increase productivity of soybean and corn.

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