Reducing Input Costs with Multiple Enterprises

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Summary

Integrating crop and livestock enterprises can enhance the economic and environmental sustainability of agricultural production units in the Great Plains. Production of forage is essential for successful integration of both enterprises. Forages offer soil and pest management benefits when incorporated and managed properly in rotations with grain and seed crops. Moreover, forages can provide traditional grain and seed crop producers with access to new markets. Nevertheless, less than 10% of agricultural land in the Great Plains is dedicated to integrated crop-livestock systems. Lack of broad regional application, government incentives, managerial expertise, suitable farm-ranch infrastructure, and tradition have been identified as obstacles to developing integrated crop-livestock systems. Recent concerns about the bio-security of domestic food production systems, unstable fertilizer and fuel prices, a growing demand for multi-disciplinary research, and other factors have renewed interest among crop and livestock scientists in developing integrated agricultural systems. Unfortunately, the discontinuation of many long-term rotation studies, beginning in the 1950s, has resulted in a general lack of current research on integrated crop-livestock systems in the context of emerging crop production methods. Moreover, there has been a tendency among crop and animal scientists to work at solving problems within their discipline and to avoid interdisciplinary research. However, a few working groups of crop and livestock scientists have been formed to develop modern strategies for integrating crop and livestock enterprises in the Great Plains. Strategies range from providing forages and alternative feedstuffs to livestock that are confined for much of the year to systems where livestock are pastured on native range and in short rotations with grain and seed crops. This work must continue and should be expanded to include studies that incorporate crops, livestock, and emerging management concepts where long-term as well as short-term benefits of integrating crop and livestock enterprises can be documented. For this to occur, incentives must be provided for agricultural scientists to participate in multi-disciplinary research on integrated crop-livestock systems.

Introduction

Many cereal crops cannot be grown profitably for grain in the Great Plains without government price supports. Among small grain crops in southwestern North Dakota, for example, returns to labor and management are projected to be -$65/ha for hard red spring wheat (*Triticum aestivum* L. emend. Thell.) following fallow, -$5/ha for hard red spring wheat following spring wheat, $27/ha for durum wheat (*Triticum turgidum* L.) following fallow, -$23/ha for corn (*Zea mays* L.), and -$42/ha for oat (*Avena sativa* L.) in 2003 (Swenson and Haugen, 2002). Positive returns to labor and management are projected for durum wheat following durum wheat ($21/ha) and barley (*Hordeum vulgare* L.) grown for malt ($84/ha). Positive returns for recropped durum wheat and malting barley are an anomaly compared with recent economic experience with these two crops in southwestern North Dakota.

Many farmers have incorporated dicotyledonous crops grown for seed into rotations with cereals to improve cropping system economics in the Great Plains. Dicotyledonous crops can be grown profitability for seed in some years. For example, returns to labor and management are projected to be $11/ha for canola (*Brassica napus* L. and *B. rapa* L.), $26/ha for field peas (*Pisum sativum* L.), and $68/ha for oil sunflower (*Helianthus annuus* L.) during 2003 in southwestern North Dakota (Swenson and Haugen, 2002). Projected positive returns in 2003 contrast with negative returns projected for these three crops in 2000 (Swenson and Haugen, 1999).

Rotations comprised of dicotyledonous crops grown for seed and cereals grown for grain may not provide sufficient diversity to protect many Great Plains agriculturists from economic hardship. New production and marketing methods are needed for annual grain and seed crops to be grown profitability in the region. Agriculturists in Australia developed forage-based cropping systems to enhance the economic and environmental sustainability of grain and seed production methods, beginning in the 1930s. Similarly, a few producers in the Great Plains have developed forage-based cropping systems as alternatives to dynamic cropping systems comprised only of grain and seed crops. The positive economic impact of growing forages is reflected in a projected return of over \$120/ha for an alfalfa hay crop managed in southwestern North Dakota in 2003 (Swenson and Haugen, 2002). The projected returns from alfalfa were the largest of any crop considered in the analysis and supports serious consideration of the impact forages could have if incorporated into Great Plains cropping systems.

Materials and Methods

A review of the literature was conducted as well as interviews with knowledgeable experts to identify the potential benefits and obstacles to widespread adoption of integrated crop-livestock systems.

Results and Discussion

Possible Effects of Multiple Enterprises to Cropping Systems

Soil

Improvements to the soil can result from introducing forages into cropping systems comprised only of grain and seed crops. As a result, a yield benefit to grain and seed crops following forages occurred in several long-term rotation studies (Entz et al., 2002). In one study, yield increases of 50% or greater were reported for spring wheat following alfalfa compared with corn and other non-leguminous crops. On the negative side, sometimes yields were depressed when wheat followed alfalfa in dry western portions of the Great Plains, presumably because alfalfa depleted soil moisture reserves and subsequent recharge was inadequate to support maximum grain and seed crop yields during the following year. In some instances, a yield depression occurred after a full year of fallow separated alfalfa from a subsequent grain or seed crop. Some scientists suggest that alfalfa may have an allelopathic effect on subsequent grain and seed crops and that the presence of biocides may explain depressed yields following alfalfa (C. Campbell, 2001, personal communication).

Much of the rotational yield benefit that occurs when legumes are incorporated into rotations with grain and seed crops results from the biological N-fixing ability of Rhizobia bacteria attached to legume roots. Several conclusions can be made about the N benefits provided by legumes (Entz et al., 2002): (1) relatively short-duration alfalfa stands maximize biological N input to subsequent crops; (2) the N benefits from incorporating legumes into rotations are greatest within the first few years of seeding a subsequent crop but continue for several years; and (3) fertilizer replacement values in excess of 100 kg/ha are possible for some forage legumes even after removing a hay crop, if the regrowth is plowed under.

Legume and non-legume forages remove P and other plant nutrients from the soil, particularly when hayed. Grasses and other non-legume forages also remove large amounts of soil N. Many of the fertilizer recommendations used for forages are based on old studies that may not apply to modern cultivars and production systems. This is particularly true in drier regions where only small amounts of N and possibly P fertilizer generally are applied to forage. Soil nutrient management is confounded when forages are grazed, since some recycling of nutrients occurs as forages are consumed and urine and feces excreted. Animal behavior and distribution may further complicate the situation with an uneven pattern of grazing and excretion across the landscape.

A positive impact of forages on soil physical properties probably contributes to the yield benefit that results when forages are included in rotations with grain and seed crops. Aggregate stability and soil microbial activity were enhanced in soils when forages were included in rotations compared with soils in which rotations consisted only of annual grain and seed crops (Entz et al., 2002). There is some concern that grazing forages may degrade soil structure and other physical properties because of animal trampling. No studies demonstrating the impact of grazing on soil physical properties have been conducted within a dynamic cropping system context, but comparisons of intensive and extensive grazing methods suggest that animal trampling may not be as deleterious to soil structure as widely believed (Entz et al., 2002).

Pests

Integrating livestock into cropping systems can reduce the buildup of pests compared with cropping systems consisting only of grain and seed crops. Weed suppression may result when forages are incorporated into rotations with grain and seed crops (Entz et al., 2002). Canada thistle [*Cirsium arvense* (L.) Scop.], wild mustard (*Brassica* kaber (DC.) L.C. Wheeler), and wild oat (*Avena fatua* L.) populations were lower in commercial cereal (predominately wheat) fields where the cereal crop was preceded with an alfalfa hay crop compared with another cereal crop (Ominski et al., 1999). Weed population shifts may or may not occur when forages are incorporated into rotations with grain and seed crops, depending on the combination of forage, grain, and seed crops that are grown. Weed population shifts probably are greatest when perennial forages are incorporated into rotations with grain and seed crops, but population changes have occurred even when annual hay crops were introduced into rotations (Entz et al., 2002).

The impact of forage hay crops on weeds in cropping systems has been studied in the Great Plains, but little is known of the impact of grazed forages. A review by Martin (1996) suggested that grass weed invasion is reduced by grazing with cattle in legume pastures in Australia in systems where a legume pasture phase is rotated with wheat. Similarly, fewer grass weeds were observed in legume pasture that was grazed with sheep compared with legume pasture that was not grazed in California (D.W. Pratt, 1999, personal communication). These studies indicate that grazing and forage production have weed control benefits, suggesting a possible additive effect when both are combined in rotations with grain and seed crops. The impact of grazing on weed populations in dynamic cropping systems has not been demonstrated in the Great Plains region, nor have potential problems associated with this practice. For example, any weed control benefits provided from grazing perennial legume pastures may be offset by depletion of stored soil-water reserves if grazing management and forage production are not monitored carefully.

The importance of rotational diversity on controlling disease pests in cereals has been demonstrated in the Great Plains. Rotational diversity was effective in reducing the incidence of both foliar and root disease in spring wheat in several studies (Carr, 2002). Common root rot (*Helminthosporium* and *Fusarium* spp.) severity was reduced when red clover (*Trifolium pretense* L.) was grown between two wheat crops in a red clover-spring wheat-canola (*Brassica napus* L.)-spring wheat rotation compared with a continuous wheat monoculture in one of these studies. Research is needed to determine the impact of legume forages on disease in dicotyledonous seed crops when both crop types are included in diversified cropping systems, particularly since many legume forages and several dicotyledonous seed crops are susceptible to white mold [*Sclerotinia sclerotiorum (*Lib.) De Bary]. Tanaka et al. (2002) described a crop matrix technique in which disease severity for white mold and other plant pathogens was assessed across all possible combinations of 10 crops over a 2-yr period at Mandan, ND. The technique provided excellent information on disease potential among numerous crops in short crop sequences. The model can be accessed at the USDA's Northern Great Plains Research Laboratory's web page (http://www.mandan.ars.usda.gov/Crop-Seq/CropSeq. htm [verified 18 April, 2003]). However, the crop matrix technique is limited to annual crops and does not provide information on the impact of forages on plant disease beyond a 2-yr period.

Few studies have focused on how forages impact insect pests in subsequent crops. This work is needed so unintended negative consequences of introducing forages into rotations with grain and seed crops can be avoided. For example, introducing western wheatgrass (*Agropyron smithii* Rydb.) and other forage grass species into rotations with spring wheat could accentuate problems with wheat stem sawfly (*Cephus cinctus* Norton), since many forage grass species are susceptible to the pest. Conversely, incorporating dicotyledonous forages into cereal rotations may reduce certain insect pests, particularly if the cereal insect pests are poor migrators.

Economic returns

Several studies show that economic benefits may result when forages are inserted into cropping systems comprised of grain and seed crops. An economic analysis of a long-term Canadian study showed that input costs were lower for crop production systems that included forages compared with continuous grain production (Entz et al., 2002). Incorporating forages into rotations with grain crops reduced income variability and provided a biological solution that was superior to crop insurance for stabilizing net farm income in Canada. Summaries of other studies showed that profitable returns could be generated up to 50% of the time by 6-yr rotations containing forages.

A summary of crop and livestock research in south central North Dakota concluded that synergies can occur when crop and livestock enterprises are integrated (Anderson and Schatz, 2002). These researchers concluded that beef cows can consume low-value or even unmarketable feeds and forages in an integrated system. Crop residues, screenings, and other by-products of the crop enterprise were used to lower cow/calf feed production costs in several studies. Seeding grain and seed crops with the intent of producing forage was suggested as an alternative to harvesting and selling grain and seed when crop prices are low. Although theoretically appealing, no studies comparing systems where crops are grazed and where crops are harvested for grain and seed were included in the research summarized by Anderson and Schatz (2002).

Current Importance of Forages in Great Plains Cropping Systems

Alfalfa and other forages are grown throughout the Great Plains. Over 11 million ha of cultivated hay and pasture were produced in North Dakota, South Dakota, and Montana along with three Canadian provinces (Alberta, Manitoba, and Saskatchewan) alone in 1999 (Entz et al, 2002). In addition, approximately 44 million ha of native rangeland was grazed by livestock. While perennial grasses and legumes (e.g., alfalfa) are widely grown for forage, annual crops like small grains also are grazed, ensiled, and hayed. We estimate that over 250,000 ha of small grains were harvested for forage in Montana, North Dakota, and South Dakota in 1999 (unpublished data).

A substantial number of farms exist that include both crop and livestock enterprises, although empirical data on the number of these farms are unavailable. Crop and livestock systems generally are managed as separate operations with little integration on most farms where both enterprises exist. Krall and Schuman (1996) estimated that less than 10% of the land base is devoted to integrated crop-livestock production in the region. As a result, synergies that can develop between crops and livestock in an integrated system do not occur.

Obstacles to Multiple Enterprise Systems in the Great Plains

Several barriers prevent the widespread adoption of integrated crop-livestock systems in the Great Plains. Krall and Schuman (1996) pointed out that integrated crop-livestock systems are adapted to specific agro-climatic zones. Twelve agro-climatic zones exist in the northern Great Plains alone (Padbury et al, 2002). Integrated crop-livestock systems that are developed must function across the range of climatic and edaphic factors among the 12 agro-climatic zones in the northern Great Plains. Even greater differences exist among agro-climatic zones when the entire Great Plains region is considered, suggesting that practices suited to integrated crop-livestock systems in northern portions of the Great Plains may not be suited to southern portions, and vice-versa. Still, general principles may be applicable to integrated crop-livestock systems across the region (e.g., forage legumes should be incorporated into cropping systems for soil N benefits). Few government incentives exist which promote forage production or the integration of crop and livestock systems, particularly for crop producers. Government price support programs are extended to a relatively few crops when planted for grain or seed but price supports are not available if these same crops are planted intentionally for forage (e.g., corn). Thus, individuals committed to producing forages can expect no government assistance related to their forage production.

A trend toward highly specialized production systems in agriculture has occurred in the Great Plains and across North America over the past several decades. Many farms that formerly produced both crops and livestock have focused on developing one enterprise and eliminated the other. Managerial expertise and other resources generally are allocated to either crop or livestock production, even on farms where both enterprises still exist. As a result, knowledge of how to integrate crop and livestock enterprises, and even why integration may be beneficial, has been lost among many commercial crop and livestock producers.

The historic decoupling of crop and livestock systems has not been confined to commercial farms. Beginning in the 1950s, many long-term crop rotation studies that included forage phases were discontinued. Those that were continued tended to emphasize grain and seed crops over forage production. Few new studies were begun and those that were generally failed to incorporate contemporary system components (e.g., no-till). As these studies evolved, appreciation and understanding for the forage component of these rotations sometimes was forgotten. Often, forage phases in the rotations were replaced by annual grain and seed crop phases to reflect changes in Great Plains cropping systems. The replacement of forage with annual grain and seed crops eliminated the need for crop scientists to interact with animal scientists regularly on livestock needs relating to crop growth and development. Animal scientists focused their attention on livestock production in perennial pasture and confinement situations. As has occurred on commercial farms, knowledge and appreciation of integrated crop-livestock systems were lost on research facilities among crop and animal scientists.

The infrastructure that once supported many integrated crop-livestock systems no longer exists on many farms, in rural communities, or within agricultural experiment stations. For example, Krall and Schuman (1996) pointed out that watering systems and fences would either have to be improved or installed before livestock grazing could become part of an integrated system on many farms in the Great Plains. Similarly, sale barns and slaughter facilities no longer exist in many rural communities where producers can sell livestock which then can be processed and sold locally. The physical reintroduction of livestock onto many farms in the Great Plains would be difficult unless adequate infrastructure is provided so livestock can be produced profitably.

The successful integration of crop-livestock systems presently is contrary to the modern beliefs that production efficiency is optimized by specialization and production efficiency equates to economic and environmental sustainability in agriculture. These convictions have been questioned recently by agriculturists (Karn et al., 2003). Still, convictions about agricultural systems can be difficult to change even when there is ample scientific evidence suggesting that current systems should be modified or replaced. The economic and environmental inefficiencies of wheat-fallow have been documented in the northern Great Plains for decades (Ali and Johnson, 1981; Haas et al., 1974), but not until the 1990s was the wheat-fallow system replaced with dynamic cropping systems as the dominant production method for wheat in North Dakota.

Rediscovering the Benefits of Multiple Enterprises

The benefits of integrating crop and livestock on farms have been described recently by several commercial farmers (Armitage, 2003; Brown, 2003; Rampton, 2003). The producers discussed different methods of combining crop and livestock enterprises on the farms to enhance profitability and improve environmental stewardship. Likewise, an invitation to discuss the advantages of planting annual crops for forage in the Great Plains at the 92nd annual meeting of the American Society of Agronomy was extended to scientists working in the region (D. Baltensperger, 2003, personal communication), suggesting that agricultural researchers may be rediscovering the value that forages offer when included in Great Plains cropping systems.

Emerging cultural events suggest that integrated crop-livestock systems may gain enhanced prominence in the future. Animal and human health concerns related to large confinement operations are growing and recent concern over attacks on the domestic food supply by bioterrorists supports a decentralized approach to livestock management that could be provided with integrated crop-livestock systems, particularly if forages were grazed by livestock. Reliance on forage legumes and animal manure to provide N and other plant nutrients for subsequent crops may reduce reliance on synthetic fertilizers. Thus, the inclusion of legume and non-legume forage crops may also reduce the need for pesticides in subsequent grain and seed crops if forages are managed properly.

Fertilizer and pesticide purchases are among the highest variable costs associated with grain and seed crop production in the northern Great Plains (Swenson and Haugen, 2002). A reduction in these purchases within an integrated crop-livestock system could lower production costs associated with grain and seed crop production, if the additional costs of producing forages were more than offset by the reduced costs for fertilizer and pesticides. Production costs might be reduced further if forages are grazed and not hayed, since cutting and baling machinery may not be needed or used only sparingly. An added benefit of integrating crop and livestock enterprises might be decreased reliance on nonrenewable forms of energy (i.e., fossil fuels), since fertilizer and pesticide applications along with machinery use may be reduced. Reducing fertilizer and pesticide inputs could result in a loss of jobs in local agribusinesses, but jobs also may be created for knowledge-based consultants or in processing operations.

There are growing expectations for scientific research to be multi-disciplinary so that the complex problems that confront modern society can be addressed. This expectation exists in many competitive grant programs within agriculture (e.g., the Sustainable Agriculture Research and Education [SARE] program administered by the United States Department of Agriculture). For example, projects that included holistic approaches involving interdisciplinary teams were solicited in the most recent call for research and education proposals (SARE, 2003). Similarly, the National Research Initiative encouraged multi-disciplinary projects in its call for new proposals (NRI, 2003). By definition, integrated crop-livestock research involves a minimum of two distinct disciplines (animal and crop sciences) and should involve several more (e.g., economics, pathology, range science).

Integrated crop-livestock systems should reduce the economic risks associated with relying on either enterprise exclusively. The diversification provided by integrated crop-livestock systems can protect producers from the ‘bust’ phase of the boom/bust cycles that occur with both crop and livestock enterprises. As a result, integrated crop-livestock systems can stabilize farm income, thereby making short-, medium-, and long-term economic plans easier to project and to follow.

Challenges and Opportunities for Scientists

A search of the current CRIS database reveals several projects dedicated to integrated crop-livestock research (CRIS, 2003). However, only a few of the projects are located in the Great Plains. Moreover, the formation of multi-disciplinary teams (including animal and crop scientists) to work on integrated crop-livestock systems is limited to a few USDA-ARS facilities and land grant universities in the region. Efforts must be made to expand the formation of multi-disciplinary scientific teams capable and willing to integrate crop and livestock enterprises into agricultural systems that are adapted to the Great Plains.

A major obstacle to effective integrated crop-livestock systems research is limited funding. Few, if any, competitive grant programs fund projects for longer than three years because of the need to demonstrate short-term results to oversight committees. Funding for long-term projects is possible, but only if short-term results can be generated. Many researchers choose to develop and execute 1- to 2-yr projects in which solutions can be generated for problems caused by one or just a few factors. Unfortunately, the complexity of many integrated crop-livestock systems prohibits the development of projects that can be completed within a 1- to 2-yr period. Even the application of treatments cannot be completed within a 2-yr period in crop rotation studies where grazed forage is cycled with both grain and seed crop phases. A competitive grant program is needed that supports medium- and long-term projects. Development of a grant program supporting medium- and long-term research would not only address a major obstacle to integrated crop-livestock systems research in the Great Plains, but also to crop rotation studies in general.

Integrated crop-livestock projects are interdisciplinary by nature. Therefore, successful projects require scientists from various disciplines to work together at solving problems. Getting a diverse group of scientists to work for common solutions to problems can be challenging, particularly when there are few incentives to do so. Public funding along with grant-funded opportunities for long-term, multi-disciplinary research on integrated crop-livestock systems would encourage cooperation among animal, crop, and other scientists. For example, an interdisciplinary team of agronomists, animal scientists, range scientists, systems modelers, and others in Montana, North Dakota, South Dakota, and Wyoming was formed as part of the Four-State Ruminant Consortium Project. The goal of this team is to couple traditional agronomic research with non-traditional animal interfaces so truly integrated crop-livestock systems can be developed. Undertaking this multi-disciplinary effort would not have occurred without a special-grant request for synergistic crop and livestock systems research.

Geographical and political restrictions can limit the ability of researchers in the Great Plains to cooperate on integrated crop-livestock systems. For example, the awarding of funds for research and education projects in the SARE program occurs within the four geographic regions in the country that are defined by the program. Some states within the Great Plains reside in the Western Region (e.g., Wyoming) while other states in the Great Plains reside in the North Central Region (e.g., North Dakota) as defined by SARE. There generally is little willingness to support projects that extend across the regional boundaries delineated by SARE, even if the current boundaries ignore agro-climatic zone delineations. Similarity, there is little support for cooperative research between scientists in Canada and the USA, even though the agricultural systems and problems that are encountered are similar in the Great Plains region across both countries.

Great advancements in integrated crop-livestock research can occur if barriers are removed that currently prevent cooperation between scientists across the Great Plains. These advancements will result in multiple enterprise systems that improve the environmental stewardship of agricultural land throughout the region. Development and implementation of adapted integrated crop-livestock systems will contribute to the sustainable agriculture vision that is being defined for the Great Plains.

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