Ley Farming: A Systems Approach to Integrating Crop and Livestock Enterprises

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Research Summary

Integrating crop and livestock enterprises can enhance the economic and environmental sustainability of agricultural production in the Great Plains. The development of ley farming, where wheat (*Triticum aestivum*) and legume pasture are rotated, created biological and economic synergies between crops and livestock enterprises in Australia. Preliminary research indicates that ley farming may be adapted to the region encompassed by the Four-State Ruminant Consortium (4-SRC). However, methods must be modified and new strategies developed before ley farming has the potential for widespread adoption in the region. The objectives of this project are to: (1) identify legume species best suited for grazing when placed in short rotations with grain and seed crops; (2) refine methods to ensure consistent success in establishing and grazing high-quality legume stands during the pasture phase; (3) document the impact of ley farming on wheat grain yield and quality as well as livestock performance; (4) determine the economic costs/benefits generated from ley farming compared with alternative crop and livestock systems used commonly in the region; and (5) develop a ley farming working group that includes a web-based interactive forum for crop and livestock producers, researchers, and others interested in ley farming in the region encompassed by the 4-SRC. On-site tours along with producer demonstrations will provide an additional outreach component exposing producers and others to the benefits offered by ley farming if adopted in the region. Results of this project will demonstrate that ley farming offers biological and economical advantages compared with alternative methods of crop and livestock production, is adapted to the region, and can serve as a stimulus for the development of a working group of successful ley farming researchers and producers willing to assist others in adoption of this integrated crop-livestock system.

Introduction

The region encompassed by the 4-SRC resides within the northern Great Plains, a vast area that includes about 8 million hectares of cultivated hay and pasture land (Entz et al., 2002). A large portion of the region also is devoted to dryland production of grain and seed crops. For example, wheat production totaled 6.6 million ha within Montana, North Dakota, and South Dakota during 2003 (E. Stabenow, personal communication, 2004). Although these data indicate that both crop and livestock enterprises are widespread across the region, Krall and Schumann (1996) estimated that less than 10% of agricultural land is dedicated to integrated crop-livestock systems. The lack of integrated crop and livestock enterprises prevents benefits in environmental quality, economic diversity, and pest management from occurring that can result when enterprises are integrated (Krall and Schumann, 1996). For example, Entz et al. (1995) reported wheat yield enhancements and weed pressure reductions when forages were incorporated into rotations with wheat and other grain crops. Additional benefits and synergies between crop and livestock enterprises can occur when grazed pasture is rotated with wheat and other grain crops (Entz et al., 2002). A review by Martin (1996) suggested that grass weed invasion was reduced by rotating grazed legume pastures with wheat compared with cropping systems which did not include grazed pasture.

Production economics must be improved in the region encompassed by the 4-SRC for crop and livestock enterprises to remain viable on many farms and ranches. Cereal crops can no longer be grown profitably for grain in the region without government price supports. For example, returns to labor and management in southwestern North Dakota were projected to be -$65/ha for hard red spring wheat following fallow, -$5/ha for hard red spring wheat

following spring wheat, -$27/ha for durum wheat (*T. turgidum*) following fallow, -$23/ha for corn (*Zea mays*), and -$42/ha for oat (*Avena sativa*) in 2003 (Swenson and Haugen, 2002). In contrast, returns to labor and management for beef cows or backgrounded calves in North Dakota were reported to average $65 and $15 per head, respectively, in 2002 (A. Swenson, personal communication, 2004). Thus, beef cattle offer one possible avenue for marketing forage produced in an integrated cropping system. If the cropping system is able to provide higher quality forage to grazing cattle later in the grazing season, livestock performance may be enhanced, thus becoming mutually beneficial to both system components.

Integrated crop-livestock systems have been developed as a response to the environmental degradation and poor economic returns that result from single enterprise systems (i.e., crops or livestock), although not in the region encompassed by the 4-SRC. In Australian ley farming, wheat is rotated with legume pastures that both profitably and ecologically integrate cereal crop and livestock enterprises to form the foundation for flexible and sustainable dryland agricultural systems (Cocks et al., 1980). The annual medics (*Medicago spp*.) used for pasture regenerate from the soil seed bank, and in the pasture phase of the cropping sequence provide forage for sheep and cattle. In the cereal phase of the cycle, regenerating medics may briefly furnish forage before seedbed preparation for planting wheat or barley (*Hordeum vulgare*). Today, annual medics are the principal legume component on more than 20 million ha in the wheat-sheep zone of southern Australia where they provide myriad benefits to Australian agriculture including more profitable cereal production (Boyce et al., 1991), high-quality livestock forage (Mann, 1991), integrated pest management with a better break to pest and disease life cycles and weed suppression by medic swards (Loomis and Conner, 1992), reduced fertilizer inputs and improved air and water quality (Grierson et al., 1991), soil conservation and improved soil quality (Cocks et al, 1980), and the potential global benefit of C-sequestration as related to the higher primary productivity of ley farming.

The PI and two co-PIs of the grant proposal have been working with farmers and ranchers in North Dakota and Wyoming to identify legume species for use as dryland pasture in rotation with wheat since the mid-1990s. A close collaboration exists with Australian ley farming experts by virtue of exchange visits. Various legume species have been evaluated as possible candidates for ley farming in the region encompassed by the 4-SRC. This includes a range of Australian commercial cultivars and black medic (*M. lupulina*). Rigid medic (*M. rigidula)* has been identified as a promising candidate for winter annual regenerative pasture on the southeastern Wyoming Plains (Walsh et al., 2001). Birdsfoot trefoil (*Lotus corniculatus*) has been identified as a promising candidate for spring regenerative pasture in southwestern North Dakota (Carr et al., 2003). Results of small plot studies demonstrate that both legume species produce good to excellent yields of high-quality forage and can regenerate naturally from the soil seed bank even when interrupted with a wheat phase. However, methods are needed so rigid medic and birdsfoot trefoil pastures can be established consistently since the initial legume stand determines pasture productivity as well as subsequent success at pasture regeneration following a cereal crop phase. In addition, other legume species have recently been identified that also may be suited to ley farming and should be included in side-by-side comparisons with rigid medic if fall sown and birdsfoot trefoil if spring sown.

Limited grazing of rigid medic by sheep in Wyoming and of birdsfoot trefoil by cattle in North Dakota suggests that both species can be grazed successfully in the region (unpublished data). More extensive grazing studies are needed to determine if rigid medic and birdsfoot trefoil are suitable as ley pasture species in the region. Economic analyses are needed to determine if economic returns are enhanced and risks are reduced by ley farming compared with single enterprise (i.e., crop or livestock) systems.

The specific objectives of the proposed research are to:

(1) identify legumes suited for self-regenerating pasture in short rotations with wheat and other grain crops in the region encompassed by the 4-SRC;
(2) develop methods for establishing and maintaining productive, high-quality legume pasture that can be used in ley farming systems;
(3) demonstrate the benefits of ley farming on wheat yield and grain quality as well as livestock performance compared with wheat production systems which do not include a legume pasture phase and livestock grazing systems that exclude grain and seed crops;

(4) determine the economic costs/benefits generated from ley farming compared with grain-only and livestock-only systems;
(5) develop a ley farming working group that includes a web-based interactive forum for crop and livestock producers, researchers, and others interested in integrated crop-livestock systems.

Materials and Methods (listed in order of the objectives)

Legume species adaptation study (Objective 1). Rigid medic (cv. WY-SA-10343), Austrian winter pea (*Pisum sativum*), hairy vetch (*Vicia villosa*), and wooly pod vetch (*V. villosa* ssp. *dasycarpa*) in the fall and birdsfoot trefoil (two cultivars), white annual (vs. biennial) sweetclover (*Melilotus alba*), and alfalfa (*M. sativa*) as a control in the spring will be established at the NDSU Dickinson Research Extension Center in southwestern ND, at the Southern Agricultural Research Center in southeastern MT, and at the University of Wyoming's research facility near Sheridan in northeastern WY. The PI and two county extension educators (Odegaard, Salverson) also will establish the study at a commercial farm in northwestern SD. A randomized complete block design will be used with seeding date and legume treatment combinations replicated four times at each location. Pasture composition of each fall-sown entry will be assessed at approximately 60 d after sowing and again the following year with the onset of spring growth, along with dry matter production at flowering. Pasture composition of each spring-sown entry will be assessed at approximately 30 d after sowing along with dry matter production at flowering. Seed production, survival, and success at regenerating new plants from the soil seed bank will be determined using accepted methods (Walsh et al., 2001; Carr et al. 2003). The study will be conducted in each of two years, beginning with the establishment of fall seeded treatments in 2004. Data from the study will be analyzed using a general linear model across years (random) with locations, seeding date, and legume treatments considered fixed effects.

Tillage and seeding method study (Objective 2). Rigid medic and birdsfoot trefoil will be broadcast seeded with incorporation and drilled into standing small grain stubble and a tilled seedbed in the fall (rigid medic) and spring (birdsfoot trefoil) at the four locations identified in the description of the *Legume species adaptation study*. A randomized complete block design will be used with legume species (whole plot) and tillage x seeding method factorial combinations (subplots) in a split plot arrangement with treatments replicated four times. Pasture composition, dry matter production, seed yield, survival, and success at regenerating
new plants will be determined as described under the *Legume species adaptation study*. The study will be conducted in each of two years. Data from the study will be analyzed using a general linear model with legume species, tillage, and seeding method treatments considered fixed effects and years considered random.

Legume pasture preference study (Objectives 1,3). An experimental area of approximately 2.5 ha will be divided into four equal sized pastures near Dickinson in southwestern ND. Each pasture will have at least 12 experimental plots (9 m by 30 m) with enough border area to allow individual treatment establishment and maintenance. Each pasture will be subdivided into three replicates of four plots and one of four treatments randomly established within each pasture replicate. Treatments will include alfalfa, birdsfoot trefoil, rigid medic, and annual sweetclover. Each pasture will be enclosed with an electric fence including enough border area to accommodate a watering tank and mineral feeder. Water and salt will be available at all times and a poloxalene containing supplement administered daily to protect against frothy bloat. Border areas within the electric fence of each pasture but outside of the experimental plots and a 1-m strip between each plot will be clipped prior to grazing evaluations. One pasture will be designated as a conditioning or exposure pasture and the remaining three pastures used to test cattle preference among treatments. In each of two years, two grazing preference trials will be conducted using a single set of animals in each year. An adequate number of yearling heifers will be used with a stocking density sufficient to remove an average of 50% of the forage present in a 48-hr period. Grazing trials will begin in the conditioning pasture and the other pastures subsequently grazed in a predetermined sequence. The first of the grazing trials will begin in early to mid July and the second trial 28 days later in early to mid August. The first trial will involve primary growth, while the second trial will involve regrowth material. Heifers will be allowed access to each pasture for 48 h and forage measurements taken before and immediately following grazing in each pasture. Following individual grazing bouts and forage sampling, each pasture will be standardized by mechanically clipping to a uniform height. Cattle preference for specific

treatments will be determined using an estimate of consumption, a selection ratio and a preference score (Shewmaker et al., 1997). Forage measurements will include forage yield before and after grazing and the assignment of a preference score. Forage yields will be used to calculate forage consumption or removal and a selection ratio. The preference score is an ocular estimate of utilization at the termination of grazing. Scores will range from 0 (no use) to 10 (100% use). Data from each trial will be analyzed using a general linear model across years as a randomized complete block with multiple locations (pasture).

Ley farming grazing study (Objectives 3 and 4). A ley farming system (wheat-birdsfoot trefoil) has been established in 1-ha paddocks along with a wheat-pea grain production system and a wheat-alfalfa system at the NDSU Dickinson Research Extension Center in southwestern North Dakota (experimental design, treatment protocol, and statistical analyses methods are provided in the NDSU AES research project report entitled *Integrating Crop and Livestock Systems with Forages in the Great Plains* [CRIS project id ND06251]). Wheat grain yield and quality will be determined for the wheat phase of the three rotations. Livestock performance will be measured using yearling beef heifers rotationally grazing legume pastures. Accurate records of labor and management, equipment, and fuel requirements will be maintained for each paddock. Records also will be maintained of prices received for crops and livestock produced in this study. Returns will be computed considering all sources of revenue, including crop and livestock receipts and government program payments (that a farmer would receive), and all costs, including variable and investment (i.e., fixed) costs. The PI will work closely with a cooperating agricultural economist (Devuyst) to ensure that economic analyses are conducted correctly. Biological (wheat yield and grain quality) and economic comparisons will be made among the competing systems in the study. The system[s] generating greatest returns to labor and management and the system[s] requiring the least amount of risk will be identified. The returns and risk associated with ley farming and other wheat production systems will be compared with returns and risk associated with a perennial grazing system.

Ley farming working group (Objective 5).
A working group of researchers, extension service personnel, and commercial producers has formed during development of this project proposal. We anticipate that this group will become larger as studies included in this project are established, site visits are made during summer tours, and more crop and livestock producers, as well as extension service personnel, become aware of the benefits offered by integrating crop and livestock enterprises by ley farming. A portion of an information processing specialist's time has been allocated to maintaining information from this project on the NDSU Dickinson Research Extension Center's web page, with a direct link on the home page or indirectly from both the Agronomy and Beef icons at the web site. Users will be able to click on an icon and be taken to an informational page outlining the project but will have the option of accessing specific information via clickable links. A discussion forum for users to post information and questions related to this project will be provided.

The status and goals of efforts included in this project will be disseminated to regional stakeholders through annual on-site visits conducted within each of the states in the region. We anticipate that >100 farmers and ranchers will be present during the visits to studies located both on commercial farms and at research/extension centers, based on results of similar field tours hosted by the PI and Co-PIs of this project (one of whom has a 20% extension appointment). The PI and Co-PIs will work closely with extension service personnel and particularly county agents in promoting the field tours and in presenting information. Problems in promoting and conducting the tours are not expected since excellent working relationships already exist between personnel at the NDSU Dickinson Research Extension Center and extension personnel in northwestern SD and southwestern ND, between researchers at the MSU Southern Agricultural Research Center and extension personnel in southeastern MT, and between researchers at the UW Torrington Research Extension Center and extension personnel in northeastern WY.

A discussion forum for users to post information and questions about this project and ley farming will be an important part of web site development by this project. In addition to specific comments about the field studies, users will have the opportunity to share concerns, problems, and successes about integrating crop and livestock systems. Users with extensive knowledge of forage legume species will have the opportunity to discuss with users just learning or gathering information. It is anticipated that success at regeneration of new plants in the second (field

experiments established in 2005-06) and third year (field experiments established in 2004-05) after initial sowing will be monitored, but this falls outside of the proposed budgeted research.

Results and Discussion

None at this time.

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