Integrated Crop-Livestock Systems - Dickinson

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RESEARCH SUMMARY

Integrated crop and livestock systems may enhance the economic and environmental sustainability of agricultural operations on the northern Great Plains. The purpose of this study was to assess the potential that ley farming, where wheat is rotated with grazed pasture, may have in this region. Results indicate that hairy vetch has potential as a fall-seeded forage species, while other spring-seeded short-lived legumes for pasture, such as birdsfoot trefoil, may be suitable for the region in certain circumstances. Altering seeding and tillage methods had little effect on legume stands and forage yields. Wheat yields in rotation with alfalfa were significantly less than wheat in rotation with pea or birdsfoot trefoil over a five year period. Soil nitrate content tended to be lower in the wheat/alfalfa rotation, while soil bulk density was similar between the rotations including a grazing phase (alfalfa-wheat and birdsfoot trefoil-wheat) and the rotations without a grazing phase (wheat-pea). Cattle preferred rigid medic to alfalfa, birdsfoot trefoil, and yellow-flowered sweetclover in grazing trials.

INTRODUCTION

The concept of ley farming, where livestock and crop enterprises are integrated into a whole-farm system, is one that holds promise for North American farmers. The system is defined by the inclusion of legume pasture in the crop rotation, which ideally regenerates after the grain, seed or vegetable phase of the rotation. The modern version of this system has its origins in Australia, where the integration of sheep pasture into the cropping rotation has been determined to be an ecologically sound alternative to the wheat-fallow system. Until recently, wheat-fallow has been the dominant cropping system in semi-arid areas of Australia and North America for some time. However, soil erosion and loss of organic matter associated with black fallow, and the high price of herbicides associated with chemical fallow, has discouraged its use. Economic inefficiency is another reason that many producers have moved away from wheat-fallow.

The historical success of ley farming in semi-arid regions of Australia evinces the relevance of this cropping system for semi-arid regions of the North American Great Plains. Developing strategies for the implementation of ley farming on the Great Plains depends upon a careful assessment of the system in this region, including: (1) the identification of self-regenerating legume species suitable for rotation with small grains and adapted to the climatic conditions of the region, along with the determination of appropriate techniques for seeding legume stands;(2) an evaluation of the efficacy of integrating livestock pasture on enhancing soil quality through the addition of crop residues and atmospherically fixed nitrogen, translating into commensurate or increased wheat yields and heightened economic efficiency as compared with cropping systems lacking a legume pasture phase, and; (3) to determine cattle preference for suitable legumes.

MATERIALS AND METHODS

Legume suitability screening and methods for establishment

To evaluate the efficacy of integrated crop-livestock systems for southwestern North Dakota, it was necessary to identify suitable legume species based on local climatic conditions. In order to determine forage yield potential in the region, eight legume species were evaluated at the Dickinson Research Extension Center, as well as at a site in northwestern South Dakota (data combined; Table 1). Additionally, it was necessary to determine the appropriate techniques for seeding and maintaining productive legume pasture. The effect of tillage linked with seeding method on seedling density and dry matter yield of rigid medic (cv. WY-SA-10343) and birdsfoot trefoil (cv. Norcen) was investigated (Fig. 1 and 2). These species were chosen due to their potential for regeneration from the soil seedbank after the small grain phase of a rotation. Rigid medic has a prostrate growth habit in southwestern North Dakota that makes haying of this species impractical. Still, trials in Wyoming have identified this legume as having potential in legume pastures. The influence of different tillage regimes, including ‘conventional till’ (spring and fall tillage), 'reduced till' (spring tillage only) and 'no till', on the seedling density and dry matter yield of alfalfa (cv. Travois) and birdsfoot trefoil (cv. Norcen) was also investigated in a separate study (Fig. 3 and 4).

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An integrated crop-livestock system was implemented at the Dickinson Research Extension Center. The system included three crop rotations: wheat-alfalfa-alfalfa (WAA), wheat-birdsfoot trefoil-birdsfoot trefoil (WTT) and wheat-pea (WP). In the wheat-alfalfa rotation, grazing took place in both alfalfa years, while in the wheat-trefoil rotation, grazing took place only in the second trefoil year. In the wheat-pea rotation, both crops were harvested for grain.

Legume grazing preference

Cattle preference for several legumes identified above as potential species for use in crop-livestock systems was determined. Heifers were given equal access to swards of rigid medic (cv. WY-SA-10343), birdsfoot trefoil (cv. Norcen), alfalfa (cv. Travois) and annual sweetclover (cv. Hubam) and allowed to graze for 48 hr. Forage consumption was determined by sampling crop stands before and after the grazing period and by observing the cattle for periods during daylight hours and noting their location with respect to crop species.

RESULTS

Legume suitability screening and methods for establishment

As indicated by Table 1, hairy vetch was the only fall-seeded legume to produce adequate amounts of forage for grazing in the year subsequent to seeding. When spring seeded, however, hairy vetch performed no better than any other variety. Woolypod vetch tended toward greater forage production among the spring-seeded varieties, while both trefoil cultivars tended to produce less forage. However, the absence of statistically significant differences between forage yields makes it difficult to draw strong conclusions as to the best performing variety. The lack of statistical significance is the result of each variety producing largely variable yields, which is indicated by the high coefficient of variation (CV).

Seeding method, whether drilling into a no till bed or broadcasting onto a tilled bed, had no significant effect on the seedling density of rigid medic or birdsfoot trefoil (Fig. 1 and 2). In earlier studies, rigid medic was fall planted, but this resulted in almost complete winter kill of seedlings. When spring-seeded, however, this species generated significantly higher yields than birdsfoot trefoil under both seeding methods, even though seedling density was significantly lower. Incidentally, seedling density was very low for both species. Based on the amount of live seed planted, germination rates were approximately 10% for rigid medic and slightly less for birdsfoot trefoil. The most probable explanation for these low germination rates was inadequate moisture at the time of seeding.

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Crop rotation generally had no effect on wheat yields (Table 2). In 2004, however, wheat yields in both the WTT and WAA rotations were significantly less compared to the WP rotation. Additionally, 2004 wheat yields from the WAA rotation were significantly less than wheat yields from the WTT rotation. These differences in 2004 contributed to an overall reduction in wheat yields in the WAA rotation as compared to the WP rotation when all years were combined.

The effect of rotation on nitrate nitrogen (NO_3) levels as sampled the fall before each wheat phase was also determined (Fig. 3). Although NO_3 levels at the 0-6 in depth did not differ significantly in every year of the study, a trend towards significantly lower NO_3 levels in 2003 and 2004 was apparent at the 0-6 in depth in the WAA rotation. Trends in NO_3 levels over time did not differ between rotations in the 6-24 in depth; however, when both depths were combined trends in NO_3 levels in the entire 0-24 in depth echoed the trends in the 0-6 in depth (data not shown). The downward trend in NO_3 levels in the WAA rotation is further evidenced by the significantly greater amounts of fertilizer needed per year to achieve a 40 bu/ac yield goal in this rotation (Table 3). It should be noted that wheat yields in any rotation never reached 40 bu/ac; this attests to the fact that this yield goal is overly ambitious and must be adjusted to mitigate instances of over-fertilization.

Rotational system was also observed to have an effect on soil bulk density, with soils in the WTT rotation possessing a higher bulk density than those in the WAA rotation (Table 4). Soil bulk density is often assumed to increase with the inclusion of grazing in a no-till rotation; however, in this study neither rotation including a grazing phase differed in soil bulk density from the rotation with no grazing phase.

Legume grazing preference

According to the crop sampling method for determining grazing preference, rigid medic was grazed more heavily than birdsfoot trefoil or sweetclover (Table 5). No significant difference in grazing preference was observed between rigid medic and alfalfa. Visual observation of cattle during grazing periods again revealed a greater preference by cattle for rigid medic as compared to birdsfoot trefoil or sweetclover (Table 6). In conjunction, this method also indicated a greater preference for rigid medic compared with alfalfa.

Table 1. Mean fall- and spring-seeded legume yields (lb/ac).

Variety	Fall Seeded	Spring Seeded
Hairy vetch	1549*a*†	1334*a*
Austrian winter pea	125*b*	2286*a*
Woolypod vetch	0*c*	2549*a*
Rigid medic	0*c*	2106*a*
Alfalfa	--	1428*a*
Annual sweetclover	--	1062*a*
Norcen trefoil	--	895*a*
Leo trefoil	--	837*a*
CV%	>100	74

† Treatments in the same column with the same letter are not significantly different at $p = 0.05$.

Table 2. Influence of rotation on wheat yields.

Rotation	Year					
	2003	2004	2005	2006	2007	All Years
	(bu/ac)					
WP	33*a*†	33*a*	35*a*	36*a*	31*a*	33*a*
WTT	29*a*	27*b*	36*a*	25*a*	24*a*	28*ab*
WAA	29*a*	19*c*	35*a*	27*a*	27*a*	27*b*

†Within columns, means followed by the same letter are not significantly different at $p = 0.05$.

Table 3. Average amount of fertilizer (11-52-0 and 34-0-0), based on fall-sampled soil tests, needed per acre in the wheat year of each rotation to achieve a 40 bu/ac yield goal from 2003 to 2006.

Rotation	Fertilizer Needed (lbs)
WAA	283a†
WTT	199b
WP	152b

†Within columns, means followed by the same letter are not significantly different at $p = 0.05$.

Table 4. Influence of crop rotation on soil bulk density.

Rotation	Soil Bulk Density
WTT	1.4a†
WP	1.3ab
WAA	1.2b

†Within columns, means followed by the same letter are not significantly different at $p = 0.05$.

Table 5. Grazing preference in as determined by crop biomass sampling.

Species	Preference Score
Medic	52*a*
Alfalfa	38*ab*
Trefoil	34*b*
Sweetclover	12*b*

†Within columns, means followed by the same letter are not significantly different at $p = 0.05$.

Table 6. Grazing preference in as determined by visual observation.

Cultivar	Mean % of time spent grazing
Medic	11.47*a*
Alfalfa	8.39*b*
Trefoil	6.79*b*
Sweetclover	6.68*b*

†Within columns, means followed by the same letter are not significantly different at $p = 0.05$.

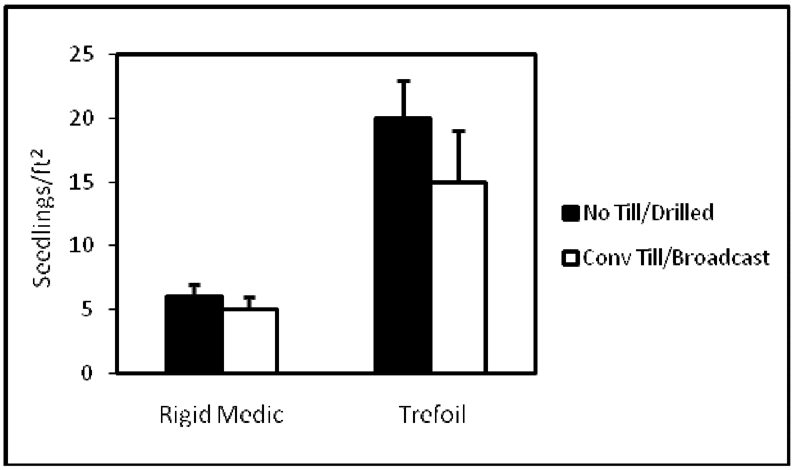

Figure 1. Influence of seeding method on seedling abundance.
Rigid Medic seeding rate: 46 seeds/ft^2 (2,000,000/acre)
Trefoil seeding rate: 138 seeds/ft^2 (6,000,000/acre)

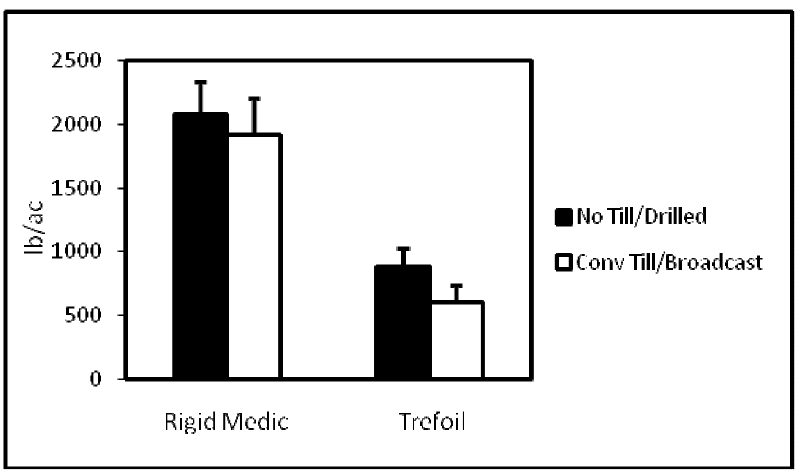

Figure 2. Influence of seeding method on legume yield.

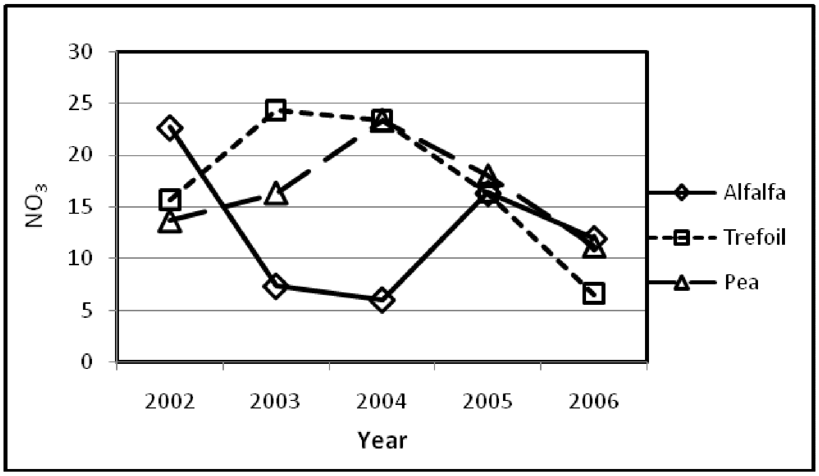

Figure 3. Nitrate levels (0-6 in) previous to wheat as influenced by crop rotation.