Substituting Medic, an Annual Legume, in Place of Summer Fallow for Winter Wheat Production

By Brian R. Lewton, James M. Krall, Bret W. Hess and Larry J. Held

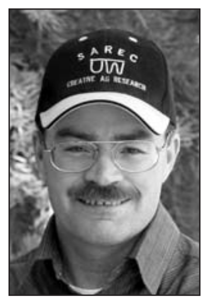
Abstract

An Australian "ley" farming type of system, which integrates medic pasture with livestock in place of conventional summer fallow, is a promising technology having the potential to provide important benefits for improving winter wheat production in the Central High Plains of the United States. Medic is an annual legume that regenerates yearly from a soil seed bank, and in the pasture phase of the cropping sequence, it provides hay or grazing for livestock. Farming systems with medics form the foundation for flexible and sustainable semiarid wheat farming systems in Australia. This article reports the performance of a specific medic specie (Medicago rigidula), which can replace fallow for more profitable winter wheat production in the U.S. Central High Plains.

Background

Most dryland cropping systems on the U.S. Central High Plains (western Nebraska, western Kansas, eastern Wyoming and eastern Colorado) still include summer fallow, which diminishes economic and ecological sustainability. Although a 14-month fallow phase associated with a traditional winter wheat summer-fallow system has generally guaranteed successful wheat seedling establishment, the system is notoriously inefficient. Usually, less than 25 percent of the precipitation received during fallow is stored in the soil for the subsequent wheat crop, and only one crop is harvested every two years (Peterson et al.). Weed control with tillage leaves a bare soil surface during the latter part of the fallow season, which intensifies both wind and water erosion. Furthermore, compared to annual cropping, tillage stimulates the loss of soil organic matter (SOM), which creates a need for supplemental nitrogen (N) for cereal crops (Haas, Evans and Miles).






Brian R. Lewton is a former graduate research assistant at the University of Wyoming. He received his B.S. degree in agricultural business and crop science from Colorado State University (2002) and M.S. degree in agricultural economics from the University of Wyoming (2005). He owns and operates a dryland wheat farm in northeastern Colorado.

James M. Krall is a professor of plant sciences at the University of Wyoming. He received his B.S. degree (1973) from Montana State University, M.S. degree (1975) from Kansas State University, and Ph.D. from the University of Wyoming (1979). His academic interests are in alternative crops, sustainable crop production, and winter wheat cultivar development.

Bret W. Hess is an associate professor of ruminant nutrition at the University of Wyoming. He received his B.S. degree (1991) and M.S. degree (1993) from the University of Nevada, and Ph.D. from the University of Missouri (1996). His research is focused on nutritional management strategies to improve production efficiency.

Larry Held is a professor of agricultural and applied economics at the University of Wyoming. He received his B.S. degree (1971) and M.S. degree (1973) from North Dakota State University, and Ph.D. from the University of Nebraska (1977). His academic interests are in farm and ranch management with emphasis on economics of sustainable farming systems.

In summary, adverse effects of fallow include lower profit potential, decreased SOM, declining soil fertility, inefficient use of the water resource, root zone leaching of nutrients, soil erosion, air pollution and surface and groundwater pollution (Peterson and Westfall).

More intensive agro-ecosystems might solve these problems by partially or completely replacing fallow. And more intensive crop rotations might increase returns and reduce long-term financial risk (Dhuyvetter et al). The term "ley," for purposes of this paper, is defined as: "The rotation of cereal crops with annual legumes for pasture or forage production" (Squires and Tows).

We are inspired by successful Australian dryland agro-ecosystems that utilize pasture with annual legumes to integrate cereal and livestock production. Australian "ley" farming systems profitably and ecologically integrate annual legume pastures into cereal crop and livestock production to form the foundation for flexible and sustainable farming systems in semiarid lands (Webber, Cocks and Jeffries). Annual medic (*Medicago* spp.) pasture alternates with wheat in much of semiarid southern Australia. Annual medics regenerate yearly from a soil seed bank, and in the pasture phase of the cropping sequence they provide forage for sheep and cattle. In the cereal phase of the cycle prior to planting wheat, regenerating annual medics may briefly furnish either forage or hay. Today, annual medics are the principal legume component on more than 50 million acres in the "wheat-sheep" zone of southern Australia where they have largely replaced fallow to provide a myriad of benefits to Australian agriculture (Squires and Tow). Benefits include more profitable cereal production (Boyce, Tow, and Kooycheki), high-quality livestock forage (Mann), self-regenerating pastures from a soil seed bank (French), improved weed suppression and integrated pest management with a better break to cereal pest and disease life cycles than provided by fallow. Other benefits are reduced fertilizer inputs (Grierson and Graham), increased plant and field water use efficiency due to better plant nutrition, improved soil water-holding capacity (Squires and Tow), improved air and water quality (Roberts), soil conservation and improved soil quality (Cousin).

After extensive evaluations of diverse annual medics, Walsh et.al. found that *M. rigidula* (a specie found at high latitudes and elevations in Eurasia and neither naturalized nor commercialized in Australia) is a promising candidate for winter annual regenerative pasture on the U.S. Central High Plains. This specie carries the necessary winter survival potential and seed survival and staggered seed-softening needed for the Central High Plains environment. It is also effectively nodulated by readily available commercial alfalfa rhizobia (Groose et al.). Very little production information has been available for winter wheat producers in the Central High Plains. Before considering this technology, wheat growers should know expected levels of forage quantity and quality of this specie over the fallow phase. This is the period when medic, as a "ley" species, will be utilized for pasture or hay production. Growing medics as a substitute for fallow has become a common practice for wheat production in Australia. Therefore, it seems reasonable to hypothesize it could be a viable practice for improving winter wheat production in the U.S. Central High Plains.

Purpose

The purpose of this article is to report the performance and profitability of medic specie *M. rigidula (cv, Laramie®)* as a substitute for summer fallow in rotation with winter wheat grown in the U.S. Central High Plains.

Data

Production data for this analysis were collected from two years of field studies (2003-2004) at the former University of Wyoming College of Agriculture's Torrington Research and Extension (R&E) Center in southeast Wyoming. It was hypothesized that *M. rigidula* could be an economic substitute for conventional summer fallow because of lower planting and seed cost after initial establishment. Medics have the ability to reproduce from a seed bank during pasture and hay cycles. Finally, medic generates additional revenue, either from pasture or hay, during the fallow phase.

Operations and Costs

Table 1 shows a calendar of operations and related costs for a conventional wheat-fallow rotation, without medic (#1), versus a six-year wheat-medic rotation (#2). It should be noted that medic is no-till planted in wheat stubble ($49/acre) in the fall after the first wheat harvest.[1] Table 1 shows that in the remaining years, medic regenerates itself, with the first primary generation[2] occurring in year two (after hay harvest), which, in turn, is followed by a secondary regeneration of medic(after grazing in year three. This sequence of medic regeneration is repeated in years five and six. Table 1 shows wheat is no-till planted in the fall, after medic hay is harvested in years three and six.[3]

Results and Discussion

Medic Hay

Both yield and quality of medic hay (*M. rigidula*) from field studies at the Torrington R&E Center, 2003-2004, were very good (Table 2).[4] Compared to a typical non-irrigated alfalfa yield in southeast Wyoming (1 ton/acre), average medic hay yield was twice as high (2.12 tons/acre). Medic hay quality was also very good compared to alfalfa, in terms of higher crude protein (19.3% vs. 18%) and higher relative feed value (R170 vs. 150).

Compared to an average alfalfa price in southeast Wyoming ($60/ton), a higher price for medic hay was estimated ($84/ton) using a University of Wisconsin hay value worksheet (Rankin), which considers premiums for crude protein and relative feed value (RFV).[5]

Medic Grazing

Once *M. rigidula* plants had reached the latter stages of seed pod development (required for replenishment of the seed bank), mature dry ewes were allowed to graze the standing crop at a stocking rate of four head per acre for 28 days (June 10 to July 7). The best practice is to allow stocking during the earlier growth phase of medic until flowering. At this point stock should be removed, allowing the plants to develop as many seed pods as possible. At the onset of grazing in this study, the average body weight of mature ewes was 174 lbs. After the mid-summer 28-day grazing period, average ewe weight was 179 lbs., thus supplying a monthly gain of 5 lbs. per acre for each ewe. This translates to a total gain of 20 lbs. /acre (i.e., 5 lbs. per head x four head). No ill effects were observed during the grazing period. We know of no other reports on the grazing of *M. rigidula*. As with other medicago species, mature *M. rigidula* is suitable forage for grazing with livestock. Further pasture research is needed to verify this finding and to determine the practices needed to maintain optimum pasture performance.

Profitability

Table 3 summarizes the average net return associated with two different wheat rotations over a common six-year cycle either without medic (#1) or with medic (#2).

Per-acre revenue ($7/acre) from grazing medic pasture is based on a gain of 20 pounds per acre from sheep times a five-year (2000-2005) average July sheep price = $0.33/lb (Wyoming Agricultural Statistics). Net Revenue of $2/acre follows from subtracting the $5/acre cost from total revenue ($9/acre).

Medic hay would generate total revenue equal to $179/acre based on average medic hay yield (2.1 tons/acre) and an estimated medic hay price ($84/ton).[6] However, assuming a more conservative price equal to regular alfalfa ($60/ton), medic hay would essentially generate lower revenue of $126/acre (vs. $179). Net revenue ($9/acre) follows from subtracting variable costs ($117/acre) for growing and harvesting medic hay. Table 3 shows a slightly higher net return from harvesting medic for hay ($9/acre), compared to grazing ($2/acre). Therefore, if the year of medic grazing were replaced with a year of medic hay, the 6-year average net return from the medic rotation would be two dollars higher (from $18 to $16/acre).[7]

Wheat yield (27 bushels/acre) is based on a historic (1980-2004) average for southeast Wyoming (Wyoming Agricultural Statistics). Wheat price ($4/bu.) is a 25-year average expressed in 2004 dollars. The per-acre cost for growing wheat in the medic rotation during year one ($109/acre) is higher than year four ($60/acre), to account for the initial $49/acre planting cost of medic, resulting in a lower net return for wheat in year one (-$1/acre) compared to year four ($48/acre). Because a seed bank is established for continued medic seed regeneration, no additional medic planting cost is required for medic production after the initial planting cost.

In summary, Table 3 shows that, substituting a medic rotation, #2 (W g h W h h) improves net return by a margin of $15/acre ($16/acre vs. $1 /acre),[8] largely because of added grazing and hay income.

It should be noted the margin of improvement is sensitive to the price of wheat because the conventional wheat-fallow rotation(#1) generates wheat income in three of six years, compared to only two of six years with the medic rotation(#2).[9]

Final Comments

We are encouraged by both the quality and quantity of spring forage produced by *M. rigidula*, when grown as a winter annual in southeast Wyoming. Replacing fallow with medic for grazing and hay production has been a common and successful practice for growing wheat in Australia. Given the recent discovery of a viable "ley" specie (*M. rigidula*), which is adaptable for production in the U.S. Central High Plains, winter wheat producers in the Central High Plains now have the option to consider medic as an improved and perhaps more profitable fallow practice, enabling them to reap similar benefits realized by wheat growers in Australia.

Endnotes

1 Winter wheat is planted during the end of the fallow phase, one year after a wheat crop is harvested. Therefore, the wheat planting cost ($22/acre) is included in the year-one fallow phase ($46/acre). Thus, without the $22/acre planting cost, the $60/acre cost for growing wheat may seem to be lower than expected. In a similar manner, the initial planting cost of medic in the fall of year one ($49/acre) is included with the $109/acre cost of growing wheat in year one in order to match the timing of planting medic in wheat stubble from wheat harvested the previous summer. Conversely, the cost of cost of planting wheat no-till ($23/acre) in medic after-math in the fall after the summer hay harvest is included in the $117/acre cost of producing medic in years three and six. It should be emphasized the economic comparison of rotations in this analysis is based on an "average" net return across a six-year rotation. Net returns, which are computed as an average over six years, will not be affected by whether the cost of planting medic is figured in the first year of wheat production or in another year.

2 *M. rigidula* medic seed, considered here, will soften during warm days and cool nights in autumn. This softening is required for germination during the fall, so that growth will take place during the spring thaw.

3 Volunteer medic usually does not become a weed problem for growing wheat because medic, by nature, is a prostrate viny plant that does not compete well within the more upright wheat canopy. This growth habit, along with herbicides for weed control in the cereal phase of the rotation, prevents medic from being a serious weed problem.

4 There can be some concern as to whether two years of data for medic hay yield and quality is adequate for a reliable economic analysis. In this case, it is worth noting that prior to the 2003-2004 medic study at the Torrington R&E Center, a preliminary study was conducted (in 1997 and 1998) to evaluate medic hay yield and quality at a different site in southeastern Wyoming (the former University of Wyoming College of Agriculture's Archer R&E Center). Medic hay performance reported from the Archer site (Walsh et. al.) was very similar to medic hay performance at the Torrington R&E Center in terms of hay yield (3 tons vs. 2.12 tons/acre), protein (19.3% vs. 22.6%) and RFV (176 vs. 150 RFV). Therefore, given the consistency of medic hay performance measures between these two sites, the medic hay performance values from the 2-year study (2003-2004) at the more recent Torrington study (as used for this analysis) are believed to be adequate for a reliable economic analysis.

5 For purposes of estimating an $84/ton price for medic hay versus $60/ton alfalfa, each 1-percent increase in protein renders a $3 price premium. Each point increase in RFV contributes a $0.50 price increase. For example, protein for medic hay (22.6%) is 4.6 percentage points higher than $60 alfalfa (18%). Better protein in this case provides a premium of $13.80/ton (4.6 x $3). The RFV for medic hay (170) is 20 units higher than $60 alfalfa (150). Higher RFV provides a premium of $10/ton (20 x $0.50). Therefore, the combined price premium from protein and RFV is $24/ton ($13.80 + $10), which yields an estimated premium medic hay price = $84/ton. ($60 + $24).

6 Selling medic hay for $84/ ton to one particular buyer may be reasonable if a complete feed analysis is available at the time of sale. However, selling medic hay for a premium price of $84/ ton to a wide range of buyers might be difficult or unrealistic at this point in time, because a general market for medic hay has not yet been tested or established. Therefore, to be more conservative, we assume a lower price ($60/ton) that is at least as high as alfalfa.

7 Because producing medic hay is slightly more profitable than grazing ($9 vs. $2 per acre), it might seem logical to substitute medic hay in place of medic grazing. While this is not impossible, employing at least one grazing component can render some additional benefits which help to sustain future medic production, in terms of livestock eating competitive weeds and pressing seed pods into the soil.

8 Assuming $4/bushel wheat, the low net return margin of $1/acre from a conventional wheat-fallow rotation is troubling, and it raises a question of why farmers would continue employ such a practice that creates poor profitability in the face of even lower wheat prices. This type of unfavorable outcome with a wheat-fallow rotation is not surprising since, by design, this system requires an idle acre of land for each acre of wheat. This poor net-return scenario underscores the need to find better production practices to mitigate poor profitability associated with conventional wheat-fallow rotations.

9 Volatile wheat prices are a complicating factor when considering a switch from conventional fallow to a more intensive medic rotation. Historically, long-term average wheat prices have been very difficult to predict. If higher- wheat prices are expected, there will be less incentive to switch away from a conventional wheat-fallow rotation.

For example, a higher wheat price ($7.50 vs. $4/bushel) will generate an equivalent six-year average net return ($48/acre) between the wheat-fallow rotation (#1) and medic rotation (#2). Conversely, if lower wheat prices are expected, the case for an extended medic rotation, becomes even stronger. Essentially, wheat prices below $7.50/bushel in this case will favor medic over conventional fallow, and vice versa. It should be further noted that the adverse impact of volatile wheat prices (in terms of more business risk and farm income variability) will be improved by diversification with the addition of more enterprises such as hay and livestock in the wheat rotation.

References

Boyce, K. G., Tow, P. G ., & Kooycheki, A. (Eds.). (1991). *Comparisons of agriculture in countries with mediterranean-type climates. Dryland farming, a systems approach*. Sydney: Sydney University Press.

Chatterton L., & Chatterton, B. (1996). *Sustainable dryland farming*. Cambridge University Press.

Cousin, R. (1997). Peas (Pisam sativan L.). *Field Crops Research, 53*, 111-130.

Crawford, E. J., Lake, A. H., & Boyce, K. G. (1989). Breeding annual Medicago species for semiarid conditions in southern Australia. *Advanced Agronomy, 42,* 399-437.

Dhuyvetter, K. C., Thompson, C. R., Norwood, C. A., & Halvorson, A. D. (1996) Economics of dryland cropping systems in the Great Plains, a review. *Journal of Production Agriculture, 9*, 216-222.

French, R.J. (1991). *Dryland Farming, a Systems Approach.* (V. Squires & P. G. Tow, Eds.). Sydney: Sydney University Press.

Grierson, I., & Graham, R. (1991). *Dryland Farming, a Systems Approach*. (V. Squires & P. G. Tow, Eds.). Sydney: Sydney University Press.

Groose, R. W., Ballard, R. A., Charman, N., & Lake, A. H. (1996). *Cold-tolerant annual medics: Medicago rigidula*. N. Am. Alfalfa Improv. Conf. Report 35, 6.

Haas, H. J., Evans, C. E., & Miles, E. F. (1957). Nitrogen and carbon changes in Great Plains soils as influenced by cropping and soil treatments. U.S. Department of Agriculture Technical Bulletin, Number 1164.

Peterson, G. A., Schlegel, A. J., Tanake, D. L., & Jones, O. R. (1996). Precipitation use efficiency as affected by crop and tillage systems. *Journal of Producation Agriculture, 9*,180-186.

Peterson G. A, Westfall, D. G. (1990). *Sustainable dryland agroecosystems*. Great Plains Conservation Tillage Symposium, Great Plains Agricultural, Council Bulletin Number 131, 23-29.

Rankin, M. (2005) Hay pricing worksheet. University of Wisconsin.

Roberts B. R. (1991). Maintaining the resource base. Dryland farming, a systems approach.

Tow, P. G., Schultz, J. E. (1991). *Crop and crop-pasture sequences. Dryland farming, a systems approach*, pp. 55-75. Sydney: Sydney University Press.

Walsh, M. J., Delaney, R. H., Groose, R. W., & Krall, J. M. (2001). Performance of annual sp annual medic species (Medicago ssp.) in southeastern Wyoming. *Agronomy Journal, 93*, 1249-1256.

Webber G. D., Cocks, P. S., & Jeffries, B. C. (1976). *Dry land farming in a semi-arid climate*. South Australian Department of Agriculture, Adelaide.

Wyoming Agricultural Statistics Service. Wyoming Agricultural Statistics, annual series, Wyoming Department of Agriculture, Cheyenne, Wyoming.

Table 1. Yearly calendar of operations and related costs for #1 wheat-fallow vs. #2 wheat-medic.

#1 wheat-fallow Rota. W-f-W-f-W-f	**YEAR #1=Wheat**	**Grow Wheat after fallow**	Per-acre costs, yr. 1=	**$60**
Spring, Jan.-Apr.	Top-dress fertilize	$22	Herbicide	$4
Summer, May-Aug.	Harvest Wheat	$24	Herbicide	$10
W-f-W-f-W-f	**YEAR # 2=fallow Repeat years #1-#2**	**Fallow prior to plant wheat**	Per-acre costs, yr. 2=	**$46**
Summer, May-Aug.	1st tillage	$8	2nd tillage	$8
Fall, Sep-Dec.	3rd tillage	$8	Plant Wheat	$22
#2 wheat-Medic Rota. W-g-h-W-h-h	YEAR # 1=Wheat	**Grow Wheat before medic planting**	Per-acre costs, yr. 1=	**$109**
Spring, Jan.-Apr.	Top-dress fertilize	$22	Herbicide	$8
Summer, May-Aug.	Harvest Wheat	$24	Herbicide	$6
Fall, Sep-Dec.			**No-till plant Medic**	**$49**
W-g-h-W-h-h	YEAR # 2 =graze	**1st primary Medic generation with grazing**	Per-acre costs, yr. 2=	**$5**
Summer, May-Aug.	Graze sheep (28 d.)	$5	--	--
W-g-h-W-h-h	YEAR # 3= hay	**1st 2ndary Medic generation with Hay**	Per-acre costs, yr. 3=	**$117**
Spring, Jan.-Apr.	fertilizer	$22	--	--
Summer, May-Aug.	Harvest hay	$67	Herbicide.	$5
Fall, Sep- Dec.	No-till plant wheat	$23		
W-g-h-W-h-h	YEAR # 4= Wheat	**Grow Wheat**	Per-acre costs, yr. 4=	**$60**
Spring, Jan.-Apr.	fertilizer	$22	Herbicide	$8
Summer, May-Aug.	Harvest wheat	$24	Herbicide	$6
W-g-h-W-h-h	YR. # 5 =hay	**2nd primary Medic**	Per-acre costs, yr. 5=	**$94**
Spring, Jan.-Apr.	fertilizer	$22		
Summer, May-Aug.	Harvest hay	$67	Herbicide.	$5
W-g-h-W-h-h	YR. # 6=hay Repeat years #1-#6	**2nd 2ndary Medic**	Per-acre costs, yr. 6=	**$117**
Spring, Jan.-Apr.	fertilizer	$22	--	--
Summer, May-Aug.	Harvest hay	$67	Herbicide.	$5
Fall, Sep-Dec.	till plant wheat	$23	--	--

Table 2. Medic, Medicago rigidula (cv. 'Laramie®' yield and quality characteristics, Torrington, Wyoming, 2003-2004

Period	Yield (tons/acre)	% Crude Protein	Relative Feed Value
2003	2.27	22.9	161
2004	1.96	22.2	179
Torr. Avg (2003-04)	2.12	22.6 (18%)[a]	170 (150)[a]

[a] crude protein=18%, and RFV=150 are the base values for $60 alfalfa. Higher crude protein 22.6%(vs. 18%), and RFV (170 vs. 150), accounted for a higher price ($84/ton) for medic hay.

Table 3. Average Net Return, given two wheat rotations, without medic (#1), and with medic (#2)

otations	Yr.1	Yr.2	Yr.3	Yr.4	Yr.5	Yr.6	6-yr. avg.
1 w/o nedic							
W f W f W f[a]	**Wheat**	fallow	**Wheat**	fallow	**Wheat**	fallow	--
ield/acre	27 bu.		27 bu.	0	27 bu.	0	--
rice ($/bu.)	$4.00		$4.00	0	$4.00	0	--
ev ($/ac.)	108	0	108	0	108	0	54
ost ($/ac.)	60	46	60	46	60	46	53
et Rev./ac.	**$48**	**-$46**	**$48**	**-$46**	**$48**	**-$46**	**$1**
2, w. medic	**Yr.1**	**Yr.2**	**Yr.3**	**Yr.4**	**Yr.5**	**Yr.6**	**6-yr. avg.**
W g h W h h[a]	**Wheat**	**Medic-g**	**Medic-h**	**Wheat**	**Medic-h**	**Medic-h**	--
ield/ acre	27 bu.	20#	2.1 ton	27 bu.	2.1 ton	2.1 ton	--
rice/unit ($)	$4.00	$0.33	$60	$4.00	$60	$60	--
ev ($/ac.)	$108	$7	$126	$108	$126	$126	$100
osts ($/ac.)[b/]	109	5	117	60	94	117	84
et Rev./ac.	**$-1**	**$2**	**$9**	**$48**	**$32**	**$9**	**$16**

W represents a year of growing and harvesting wheat, f designates a year of conventional fallow, g epresents a year of grazing medic, and h represents a year of producing medic hay.

[b/] Annual costs are derived from Table 1. The higher cost for year one wheat ($109) than year four 60/acre) reflects a $49/acre medic planting cost in the fall after wheat harvest. Likewise, a higher ost for medic ($117) in years three and six than year five reflects a $23/acre cost of planting heat.