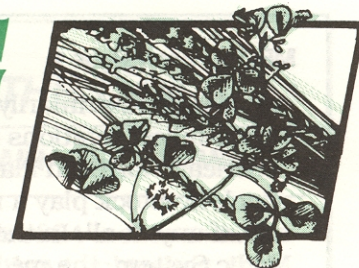


SUSTAINABLE FARMING

Quarterly



Vol. 4 No. 1 APRIL 1992

BLACK MEDIC DOWN UNDER

AUSTRALIAN - U.S. COOPERATION PROMISES NEW UNDERSTANDING OF GREEN MANURE OPTIONS

By DAVID N. OIEN, CONRAD, MONT.,
FARMER AND PARTNER IN TIMELESS
SEEDS, WHICH RESEARCHES AND MARKETS
A VARIETY OF SEEDS FOR GREEN MANURE
CROPPING SYSTEMS.

A purely serendipitous meeting between two seed companies nearly 12,000 miles apart has brought a lively exchange of ideas and a wealth of possibilities regarding green manuring in the Great Plains and Northwest region of the U.S.

Revell Seeds of Dimboola, Australia, is a 36-year-old, family-owned seed company, and the world's largest producer and marketer of annual medics. Timeless Seeds, on the other hand, is a small Montana company whose roots go back just six years to a 20-pound bag of 'George' black medic.

The differences become secondary, however, when the conversation turns to building soil fertility for cereal grain production systems in semi-arid environments. The exchange of correspondence, research materials, and two Montana visits by Revell Seeds' Brian Hedt to observe farm tours, field trials and research plots has challenged a number of misconceptions on both sides of the Pacific.

BACKGROUND

The medics, annual cousins to alfalfa and members of the leguminous *Medicago* genus, were first introduced unintentionally to Australia in the early decades of the 19th Century via imported hay and livestock. But by the 1940s and 1950s, they had become a significant factor in Australian agriculture with the development of the ley farming system.

In ley farming, annual medics are included in a flexible wheat-pasture rotation in which self-regenerating medic stands are grazed with sheep and/or cattle and are tilled occasionally (usually no more often than every third year) to be planted to cereal grains. Allowing the hard-seeded medics to set mature seed establishes a seed reserve in the soil and assures stand regeneration following one or two years of cereal grain. Exact rotation is determined by rainfall and commodity prices.

Whereas the typical crop-fallow system in Australia's hot and harsh Mediterranean climate and fragile, exhausted soils resulted in significant erosion and decline in productivity in the 1920s and 1930s, the ley system introduced

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With Addition of Carbon Residues, Such as Straw, More Isn't Always Better — Page 5.

Utah Finds Legumes Liven Up Dryland and Irrigated Soils; Researchers Excited About Miranda and Ponoka Peas — Page 7.

almost continuous soil cover, biologically-fixed nitrogen, increased grain yields, and income from livestock production.

The ley system eventually became the basis for the Montana Medic Farming System at the hands of Dr. Jim Sims of Montana State University in Bozeman. It was also the impetus for the development of the variety 'George' black medic (*Medicago lupulina*) from local wild populations. Sims' system

MEDIC, FROM PAGE 1

was designed primarily for the wheat-fallow rotations of the American Northern Plains in which livestock play a minor role, if any at all. In the Montana Medic System, the medic (seeded either on fallow ground or companion cropped with cereals) is allowed to set seed and is incorporated by cultivation during normal delayed fallow operations and seed-bed preparation. The rotation continues as the medic regenerates every second year following the cash crop portion of the cycle.

Coincidentally, in the 1970s and 1980s, structural changes in Australian agriculture — fewer and larger farms, diminished livestock profitability, and the availability of high-horsepower tractors — moved much of Australia's higher rainfall (15 to 20 inches annually) grain districts away from the ley system. However, another general leveling of yields and declining protein levels due to abandonment of soil-building practices is currently causing a return to the medics — this time as single-stand, annual green manures. Planted during each fallow cycle in a two-year grain-fallow rotation, the medics are incorporated after about 150 days, just before seed set.

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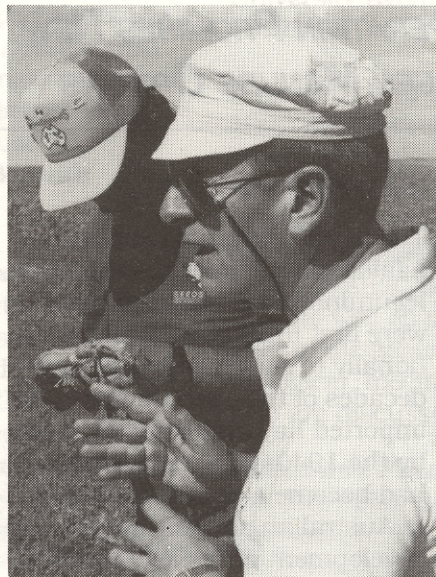
Staff: Sally K. Hilander, editor; David Granatstein, project coordinator; Allen Bjergo, Extension Service liaison.

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Until recently, the Australian and U.S. medic systems have been developing more or less independently. The former, with a long history, major governmental research support, and varietal development, is practiced on many hundreds of thousands of acres. The latter, still in its infancy, counts its practitioners in the dozens. The current cross pollination,



Brian Hedt and Phil King of Revell Seeds, Dimboola, Victoria, Australia, examine Aussie medics growing in Montana.

however, promises some new developments. While the agromomic dialogue between Revell Seeds and Timeless Seeds is only beginning, a few insights have already been gleaned. From "our" side, the most enlightening results of the exchange have been the challenge to some commonly held misconceptions about green manures. Here are a few of the most significant ones:

(1) Misconception: Green manuring is not feasible with less than 14 inches of annual precipitation.

In fact, Australians have medic systems in place with as little as 12 inches of precipitation in a

climate that is considerably hotter than our own. While management techniques may need to vary depending on rainfall, variety selection will also play a significant role in extending green manuring to our drier regions.

(2) Misconception: The bigger the better.

While touring Montana farms in 1991, Hedt thought it curious that American farmers were so impressed with lush growth of peas, lentils, and sweet clover. The Australians believe excessive top growth is detrimental, unduly transpiring moisture out of the soil. In Australia, standard practice to preserve precious soil moisture is to keep top growth to about eight inches if possible, with grazing. Additionally, prostrate medics are prized for their ability to offer a quick-shading ground cover with minimum height.

(3) Misconception: Weed control is a significant problem for green manure systems.

On my farm near Conrad, Mont., Hedt was rather disappointed to see wild oats stretching above the black medic. "Where's the livestock?" he asked, advising us that in his experience, early grazing not only suppressed weeds, but actually enhanced medic growth. Additionally, medic rotations have dramatically reduced certain weed populations on their operation.

(4) Misconception: It has taken 70 years to deplete our soil, and it'll take 70 years to rebuild it.

While in general agreement with the long-term nature of truly sustainable systems, Hedt contends significant results can also be realized in the short

MEDIC CONCLUDES ON PAGE 6

MOISTURE MONITORING WITH 'EYES BENEATH THE SOIL'

GYPSUM BLOCKS YIELD CRITICAL SOIL MANAGEMENT DATA IN SUSTAINABLE FARMING

By DAVID GRANATSTEIN, COORDINATOR OF THE SIX-STATE DRYLAND CEREAL/LEGUME PROJECT.

Since moisture is the limiting factor in crop production in most of the dryland regions, better methods to monitor the impact of farming practices on moisture conservation and use can help farmers improve their management.

A relatively simple and inexpensive tool is the gypsum block, which is buried in the soil with wires protruding to the surface. A conductivity meter is used to read the blocks and get a relative measure of soil moisture content. The blocks have been used successfully by farmers in irrigated areas, and one project in eastern Colorado has found them to be useful in dryland cereal production as well.

GROWER EXPERIENCES

During the past year, several members of Progressive Farmers Inland Northwest, a grassroots on-farm testing group in the Pacific Northwest, installed gypsum blocks on their dryland farms to test their use. Also, blocks were installed at several locations on a conservation planting demonstration near Pullman, Wash. Most blocks were read periodically through the winter and up to harvest. Farmer Dennis Pittman of Oakesdale, Wash., monitored moisture on southeast, southwest and north slopes. All sites showed full moisture recharge by March, with a quick depletion of moisture in the top three feet during June and July. The north slope showed the slowest moisture depletion, and the southwest the fastest. Larry Cochran of Colfax, Wash., monitored two adjacent strips of wheat. One was preceded by spring peas, and the other by winter canola. There was more moisture in the top 40 inches after canola compared to peas (Figure 1). The pea ground seemed to freeze much deeper than the canola ground in February, as indicated by the sharp drop in meter readings. Full recharge of the 40-inch profile was never achieved after peas, but it did occur by March after canola.

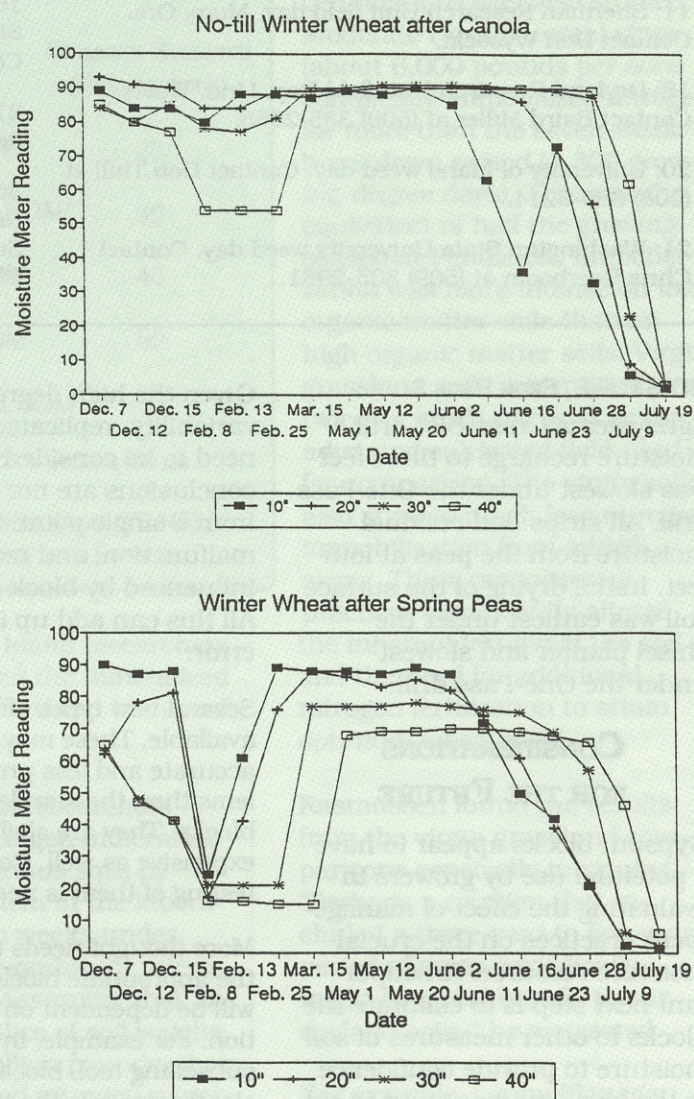
Tom Amery of Lyle, Wash., found that a field with a subsoiling in 1988 had quicker

moisture recharge at a depth of 24 inches compared to an adjacent field without subsoiling. But the latter had more moisture at a depth of 36 inches late in the season. This may be due to better infiltration and root utilization of moisture with subsoiling.

At the conservation demonstration, moisture was monitored under three systems: University of Idaho chisel planter, McGregor One-Pass drill, and

MORE MOISTURE, PAGE 4

FIGURE 1. MOISTURE MONITORING RESULTS FROM THE COCHRAN FARM, 1990-91 SEASON.



CALENDAR

The SFG is seeking calendar items for the summer issue. If you know of an event that would be of interest to other SFG readers, please send the information to AERO, 44 N. Last Chance Gulch, Helena, MT 59601 or call Sally Hilander at (406) 442-8396.

May

20: Writer/philosopher Wendell Berry will give a public reading of his work at 7:30 p.m., at the Teller Wildlife Refuge near Hamilton, Mont. Berry is a prolific writer about agricultural sustainability and land stewardship. For more information, call (406) 961-3507.

June

10: Pendleton Research Station field day, Pendleton, Ore. Contact Don Wysocki at (503) 278-4186.

11: Sherman Research Unit field day, Moro, Ore. Contact Don Wysocki.

18: Dryland Research Unit field Day, Lind, Wash. Contact Baird Miller at (509) 335-2858.

20: University of Idaho weed day. Contact Don Thill at (208) 885-6214.

21: Washington State University weed day. Contact Chris Boerboom at (509) 335-2961.

25: USDA Palouse Conservation Farm field day, Pullman, Wash. Contact Tammy Durfee at (509) 335-1552.

29: Tour of the Jess Alger farm in Montana, to view black medic rotations. Contact AERO at (406) 443-7272 closer to the event for more details.

July

1: Washington State University Farm field day, Pullman. Contact Baird Miller at (509) 335-2858.

8: Northern Montana Agriculture Experiment Station field day, Havre, Mont. Call (406) 994-3681 for more information.

9: Central Montana Agriculture Experiment Station field day, Moccasin, Mont. Call (406) 994-3681.

16: Northwestern Montana Agriculture Experiment Station field day, Kalispell. Call (406) 994-3681.

21: Eastern Montana Agriculture Experiment Station field day, Sidney, Mont. Call (406) 994-3681.

30-Aug. 1: Conference on Participatory On-Farm Research and Education for Agricultural Sustainability, University of Illinois, Urbana-Champaign. Contact John Gerber at (217) 244-4232.

MOISTURE, FROM PAGE 3

Agrisystems Cross-Slot drill. Moisture recharge to three feet was slowest under the One-Pass drill. All strips had residual moisture from the peas at four feet. Initial drying of the surface soil was earliest under the chisel planter and slowest under the One-Pass drill.

CONSIDERATIONS FOR THE FUTURE

Gypsum blocks appear to have a potential use by growers in evaluating the effect of management practices on the crucial moisture resource. An important next step is to calibrate the blocks to other measures of soil moisture to provide confidence in the block readings and to aid in interpreting the results.

Given the high degree of soil variability, replicated stations need to be considered so that conclusions are not being drawn from a single point. Blocks can malfunction, and readings are influenced by block installation. All this can add up to significant error.

Several new types of blocks are now available. These may be more accurate and less prone to problems than the standard gypsum blocks. They are slightly more expensive as well. Comparison testing of them is needed.

More thought needs to be given to the appropriate block depths. This will be dependent on the application. For example, in evaluating a subsoiling tool, blocks may need to closely straddle the tillage depth, while in a comparison of crop

rotations, evenly spaced blocks to a depth of six feet may be more useful. In monitoring a winter wheat crop, blocks to six feet may be necessary to develop a complete picture of moisture relations. Multi-year use of a block station should be examined, since the effect of installation variables should diminish over time. Several ways to bury the wires prior to tillage have been proposed, and more experience needs to be reported.

Gypsum blocks are nothing new, but they provide a low-cost way for dryland farmers to monitor moisture — their most important agricultural resource. Gypsum blocks have been called "eyes beneath the soil" and they may be a valuable addition to the toolbox for farming for profit and stewardship. □

SOIL MANAGEMENT ALTERS NATURAL FERTILITY

By DAVID GRANATSTEIN, COORDINATOR OF THE SIX-STATE DRYLAND CEREAL/LEGUME PROJECT.

The long-term plots at Pendleton, Ore., continue to provide unique insights for dryland farmers. During the past year, Paul Rasmussen and Clyde Douglas, U.S. Department of Agriculture soil scientists based at the Pendleton research station, conducted several experiments to examine the ability of soils to supply nitrogen to crops. They measured the release of nitrogen in soils with different management histories, including virgin grassland, continuous wheat, wheat to legume, and wheat to fallow with various residue and fertilizer treatments (see December 1991 SFQ for background on the Pendleton plots).

All soils have the potential to release a certain amount of nitrogen from the soil organic matter each year through normal microbial activity. This process is termed nitrogen mineralization and refers to the conversion of organic nitrogen to inorganic forms (ammonium and nitrate). The amount will depend on the organic matter level and the microbial activity. Environmental conditions that are favorable for microbial activity (warm and moist) will enhance the release of nitrogen.

But large additions of high-carbon residues such as straw can lead to a net tie-up, or immobilization of nitrogen. This occurs because the soil microbes require all the inorganic nitrogen in the soil to break down the residues. As the residues are decomposed, carbon is lost as carbon dioxide gas, and the ratio between carbon and nitrogen approaches 30:1. At this point,

inorganic nitrogen becomes available for plant use as well.

Soil organic matter typically contains about five percent nitrogen. Thus, a soil with three percent organic matter contains about 3,000 pounds of nitrogen per acre in the plow layer. Of this, about one to three percent is mineralized each year. This amount of nitrogen needs to be credited when determining fertilizer recommendations.

TABLE 1. ESTIMATES OF MINERALIZED NITROGEN FOR NORTHERN IDAHO SOILS DURING A GROWING SEASON

SOIL CONDITION	NITROGEN RELEASED (POUNDS/ACRE)
SEVERELY ERODED	20
LESS THAN 2% SOM**	30
2% TO 3% SOM	40
3% TO 4% SOM	50
MORE THAN 4% SOM	60

**SOM = SOIL ORGANIC MATTER

SOURCE: WINTER WHEAT, CIS #453,
UNIVERSITY OF IDAHO EXTENSION.

University of Idaho researchers have estimated the mineralized nitrogen for northern Idaho soils (Table 1).

The Pendleton researchers tested the nitrogen mineralization of the various soils by incubating them in the laboratory for seven weeks under conditions favorable for microbial activity. Assuming that an acre furrow slice of soil weighs about two million pounds, their results showed nitrogen mineralization of 34, 48, and 56

pounds of nitrogen per acre for wheat to fallow, wheat to legume, and continuous wheat, respectively. Those management practices that favored organic matter retention (annual cropping, nitrogen fertilization, stubble mulching, and manure addition) increased the nitrogen-supplying power of the soil. The nitrogen released during the laboratory test correlated well with soil organic nitrogen content and, in wheat to fallow systems, with nitrate mineralized during a 13-month fallow period.

The effect of residues on nitrogen relations was also studied. Moderate rates of cereal straw (about 6,000 pounds per acre) completely immobilized nitrogen for more than the seven-week breakdown period (1,300 growing-degree days). This was the equivalent of half the growing season at Pendleton. Immobilization was more intense on low organic matter soils than on high organic matter soils. Virgin grassland soils mineralized over twice as much nitrogen as the adjoining cultivated field used for comparison. The virgin soils also showed much less nitrogen immobilization from added straw. Thus, management practices significantly altered the inherent fertility of the soil and the need for additional nitrogen fertilization to attain optimum wheat yield.

Rasmussen found the results from the virgin grassland comparisons especially intriguing. "Perhaps a rotation that included a three-year to five-year period of grass periodically might be a real benefit to our dryland soils," he suggested.

For example, Lenny Flanagan, a

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term, even in low rainfall zones. Average yields on his family's 4,000-acre farm have climbed steadily from less than 40 bushels per acre to more than 60 bushels per acre, with 12 years of grain/medic management. Earthworm populations bounced back within two to four years.

The information exchange has not been one-way. Timeless Seeds' field trials in Montana, as well as university plots in various states, have broadened the understanding of annual Australian medics, and might eventually widen the soil-building niche they could fill.

To date, preliminary observations include these:

✓ **DRAMATICALLY ENHANCED GROWTH.**

Whether attributable to longer days or some other factor yet to be determined, the Australian medic foliage production may be considerably greater here than in their homeland. Upon visiting field trials of four medic varieties on the Russ Salisbury farm near Great Falls, Mont., during the first week in July, Hedt commented that he hardly recognized them as his own. After only five weeks, the medics had as much growth as would be expected after three to four months in Australia.

✓ **POSSIBLE DEFICIENCY IN NORTH AMERICAN COMMERCIAL RHIZOBIA STRAINS.**

While most Australian varieties in Montana field trials exhibited excellent growth and root nodulation with inoculant developed for black medic, Santiago burr (*Medicago polymorpha*) and Harbinger AR strand (*Medicago littoralis*) exhibited lack of viable root

nodules. Inappropriate rhizobia strains are suspected. Future developments of green manure systems will no doubt include refinements in targeting rhizobia strains to plant species and soil types.

✓ **COLD HARDINESS IS STILL A RELATIVE UNKNOWN.**

Bred for heat and drought tolerance, medics rarely are exposed to temperatures below 26 degrees F. in Australia, so their tolerance is unknown. Indications from 1991 Montana trials suggest certain varieties may tolerate much colder temperatures. Late July plantings of two Australian varieties (Ascot and Parabinga barrel medics, both *Medicago truncatula*) on my farm tolerated repeated nights below 20 degrees F. and at least one night of 12 degrees F. Both survived one mid-October night of minus 15 degrees F. with six inches of snow cover. The Parabinga was visibly frosted, but survived; the Ascot remained vital. Both were killed a few days later at zero degrees F. with no snow cover.

Frost tolerance to less than 20

degrees F. would offer the opportunity to plant the heat-tolerant medics into fallow ground during mid- to late summer and grow on into fall for winter ground cover. The following spring, a cash crop could be no-tilled into the frost-killed residue.

THE STUDY CONTINUES

While the above noted observations are necessarily preliminary, Timeless Seeds field trials examining these aspects will be continued this year. Additionally, university-sponsored legume adaptation trials of six varieties of Australian annual medics will be conducted at nine sites in Montana, three in Oregon, and one site each in Wyoming and Utah. North Dakota and Minnesota state universities are also conducting annual medic research.

The dialogue between Australia and the U.S. certainly will continue and will likely broaden and deepen as both on-farm experience and university research extend the knowledge about the application of medics in a variety of environments. □

SOIL, FROM PAGE 5

farmer from Waitsburg, Wash., has used intermediate wheat grass for a three-year period in his wheat to fallow rotation. He reports increases in wheat yields of seven to ten bushels per acre in the three crops after the grass is taken out.

While nitrogen fertilizers have been important in improving yields and maintaining soil organic matter, their use has acidified the soil in most cases. The Pendleton researchers limed several of their soils back to the original pH and found that this increased nitrogen mineralization.

Thus, while total soil nitrogen may have increased, its turnover appears to be inhibited significantly by the more acid conditions. According to Rasmussen, this implies that increased soil acidity has indeed lowered the biological activity in dryland soils, which limits their ability to supply nutrients to plants. □

UTAH LEGUMES LIVEN UP DRYLAND, IRRIGATED SOILS

BY DAVID GRANATSTEIN, COORDINATOR OF THE SIX-STATE DRYLAND CEREAL/LEGUME PROJECT.

Utah State University researchers Phil Rasmussen and Bob Newhall continue to find promising legumes for both irrigated and dryland farming.

A two-year study of Miranda protein peas has been completed using a line-source irrigation system. This system allows water application that represents a wide spectrum of conditions from very dry to very wet. From this, potential crop performance can be inferred for a range of growing environments.

The Miranda pea, which can be used as a substitute for soybean meal in livestock rations, was planted near Logan, Utah, in late March or early April at a rate of 200 pounds per acre. Irrigation rates ranged from 1.7 inches (dryland conditions) to 10 inches. Peas were harvested in late July. Pea yields steadily increased from the dryland conditions to the wettest conditions (Table 1). The protein content of the peas was not affected by the irrigation level.

An additional aspect of this experiment was the potential to double-crop a forage after the peas in the same growing season. Sorghum-sudangrass was no-tilled into the pea residue following harvest and irrigated with rations of from zero to eight inches of water. The forage was harvested as haylage in late September. In 1990, there was no yield from the dryland condition, while yields ranged from 340 to 2,260 pounds per acre of dry matter on the increasingly

wet treatments. The forage contained from 6 to 13 percent protein.

While the Miranda pea is showing promise, the Utah researchers are also excited about Poneka, the most vigorous growing new forage pea cultivar they have tried. Herbicides appear to be unnecessary because Poneka smothers weeds. Under irrigation at Logan, Poneka peas produced 7,150 pounds per acre of dry matter forage compared to 2,570 and 5,460 pounds per acre for green pea and Austrian winter pea, respectively. Intercropping Poneka or Austrian peas with oats produced maximum dry matter (over 11,000 pounds per acre) with no fertilizer or herbicide inputs.

In another study, Rasmussen and Newhall are looking for possible uses of dryland fields now in the Conservation Reserve Program (CRP). After 10 years, these fields can be returned to a use other than the perennial soil-conserving cover they now are under.

On the severely eroded areas in northern Utah, however, the soil is too degraded for viable wheat

production, so the researchers are testing several forage legumes that would require minimal inputs and support profitable livestock grazing. Three legumes — alfalfa, Cicer milkvetch, and sainfoin — are presently being

evaluated. Sainfoin appears to have the most vigorous establishment and growth (Table 2). It is also relatively inexpensive to seed. In this study, all legumes were no-till seeded in the spring, with no fertilizer added. □

TABLE 1. MIRANDA PROTEIN PEA YIELDS UNDER A LINE-SOURCE IRRIGATION SYSTEM AT LOGAN, UTAH

IRRIGATION (IN./AC.)	PEA YIELD (LB./AC.)		PERCENT PROTEIN
	1990	1991	1990
1.70	2,743	1,597	24.9
2.43	3,224	1,670	23.5
4.40	4,213	2,541	25.6
6.14	4,252	3,340	26.0
7.95	4,419	4,719	25.0
10.05	5,581	5,009	25.0

TABLE 2. FORAGE LEGUMES FOR DEGRADED DRYLAND FARMS IN CACHE COUNTY, UTAH

	DRY MATTER YIELD (LB./AC.)			SEED COST (PER ACRE)
	1988	1990	1991	
ALFALFA	—	0	1,102	\$ 7.20
CICER MILKVETCH	168	145	1,529	\$65.00
SANFOIN	—	1,041	3,683	\$10.00

RESOURCES

(THE FOLLOWING LIST OF RESOURCES IS OFFERED AS A SERVICE TO SFG READERS. THE MATERIALS INCLUDED ARE NOT NECESSARILY ENDORSED BY THE SFG OR THE DRYLAND CEREAL/LEGUME PROJECT.)

DATABASE OF ALTERNATIVES TO TARGETED PESTICIDES.

1990. J.M. Lyons, Statewide IPM Project, University of California, Davis, CA 95616-8621. Scientists at the University of California developed an inventory of alternatives to pesticides and specific crop uses that would be restricted under new federal and state law. Each record in the database represents one alternative to a crop/pest use of a targeted pesticide. The database works with FoxBASE or DBASE III.

METHODOLOGIES FOR SCREENING SOIL-IMPROVING LEGUMES.

1991. M. Sarrantonio. Rodale Institute, Emmaus, Pa. 310 pages. A guide to the process of finding the most appropriate legume species and management system for a given situation. The methods rely principally on simple tools and procedures. While the book is targeted to researchers and extension workers, many farmers will be able to perform the screening. Procedures include an initial assessment phase, a screening phase for local adaptation, screening within the cropping system, and long-term trials to assess impacts.

BIOTECHNOLOGY'S BITTER HARVEST — HERBICIDE-TOLERANT CROPS AND THE THREAT TO SUSTAINABLE AGRICULTURE.

1990. By the Biotechnology Working Group, a

national coalition of organizations concerned about biotechnology. The 70-page report documents university and industry research on herbicide-tolerant crops, and their health, environmental, social, and economic effects. Sustainable alternatives to herbicides also are discussed. Minnesota Food Association, 2395 University Avenue, Room 309, St. Paul, MN 55114. \$7.50.

INTEGRATED PEST MANAGEMENT FOR SMALL GRAINS.

1990. L.L. Strand, editor. University of California, ANR Publication #3333 Oakland, Calif. 126 pages. This publication is part of a series on major crops in California, but it is relevant to the cereal cropping region of the Northwest. It is a well-written volume with a wealth of information, as well as many figures and pictures to help in diagnosing pest problems. Cultural, biological, mechanical, and chemical controls also are discussed.

ALTERNATIVE FIELD CROPS MANUAL. 1990. Cooperative Extension Service Department of Agronomy, University of Wisconsin, Madison, WI 53706.

The manual is a loose-leaf collection of chapters on more than 35 possible alternative field crops, including buckwheat, grain legumes, oil seeds, and grains. It is targeted to upper Midwest conditions, but the information can be used to evaluate these potential crops in other environments. □

SUSTAINABLE FARMING

Quarterly



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44 North Last Chance Gulch

Helena, MT 59601

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