# SUSTAINABLE FARMING Quarterly

VOL. 4 NO. 3 OCTOBER 1992


# IT'S TIME TO STOP GROWING YOUR WILD OATS!

*BY DAVID GRANATSTEIN, COORDINATOR OF THE SIX-STATE DRYLANDCEREAL/ LEGUME PROJECT.*

Wild oat (*Avena fatua*) is a problem weed for small grain farmers throughout the Northwest dryland region. Wild oat can cause barley yield reductions from 10-40 percent. In Idaho alone, cereal producers spend $20 million to $30 million annually to control wild oat on more than 1.5 million acres of cropland.

Reduced herbicide use is being encouraged by regulations, weed resistance, and increased cost. Thus, growers need a wider array of weed control tools for the future. University of Idaho weed scientist Donn Thill and his associates have been examining several aspects of wild oat control in spring barley in order to develop a bio-economic model that can help growers maximize weed control with minimal cost and environmental impact.

A bio-economic model is used on a computer to determine the outcome (yield, crop quality, net income) from various management scenarios. Crop and weed data from a specific field are entered, along with assumptions about crop prices and weed control costs. The model helps determine which actions will lead to the most desirable outcome. But such a model must be preceded by a substantial research effort to determine the biological relationships occurring between the crop and the weed.

Thill's group has examined several management strategies that can be used in integrated control of wild oat. These include barley row spacing and seeding rate, fertilizer placement, and herbicide choice and rate. The researchers measured the growth and development of both barley and wild oat under these different management treatments. They then determined the amount of competition within a species (e.g., the effect of barley

MORE WILD OAT, PAGE 2

# FARM SOILS INSTEAD OF FIELDS

*BY DAVID GRANATSTEIN, AND BAIRD MILLER, WASHINGTON STATE UNIVERSITY EXTENSION DRYLAND AGRONOMIST.*

Looking out over a vast field of wheat in the Northwest, one can easily marvel at the uniform appearance that we credit to contemporary farming techniques. But in reality, most dryland grain fields contain a large amount of variability within their boundaries.

Growers typically manage for the average condition in the field, perhaps over-fertilizing some parts and under-fertilizing others. In either case, more precise matching of farm management to the variable conditions in a field could improve profits and reduce potential environmental problems. With the advent of powerful, compact, and inexpensive computers, many new tools are being developed to allow farmers to more precisely manage variable cropland.

Historically, land managers have recognized the specific management needs of different parts of the landscape. Steep hillsides were once left primarily for hay and pasture when most farms had livestock. The Soil Conservation Service developed the land capability classification system to encourage appropriate use of variable lands. Verle Kaiser, an eminent conservationist in eastern Washington during the 1950s and 1960s, promoted the use of an alfalfa-barley-pea rotation on the erosive upper slopes in the Palouse, and a

MORE VARIABLES, PAGE 4

## INSIDE . . .

**WILD OAT, FROM PAGE 1**

seeding rate on yield) and between barley and wild oat, and the impact on crop yield and net returns.

Barley proved to be consistently more competitive than wild oat. One barley plant is equivalent to 1.1 to 3.1 wild oat plants in terms of competitiveness for resources. Previous research has found the barley root system to be six times larger than wild oat five days after emergence and nearly 10 times larger at maturity.

Barley appears to be a better competitor than wheat against wild oat. When grown in monoculture, barley and wild oat have similar growth and development patterns, and appear to be using the same resources. But when growing together as in a crop field, barley is more competitive with wild oat than wild oat is with barley. Yet even low populations of wild oat cause reductions in barley yield.

Wild oat can exert a competitive influence on barley continually from the seedling stage to barley maturity if both plants emerge at the same time. If wild oat emergence is delayed even for several days, its competitive influence declines. But a major factor appears to be late season shading of barley by the taller wild oat that reduces light penetration during grainfill.

**TABLE 1**
**Effect of row spacing and fertilizer placement on wild oat density in spring barley, Moscow, Idaho, 1988.**

| Inter-row Width | N Fertilizer Placement Broadcast | Band |
|---|---|---|
| | —— stems/ft² —— | |
| 8" | 26 | 20 |
| 15" | 57 | 13 |

Several agronomic practices can encourage early season competitiveness of the barley and reduce wild oat competition later in the season. These include cultivation immediately before planting, increased crop seeding rate, narrower row spacing, fertilizer placement, cultivar selection, and timely herbicide application. In Idaho, the seeding rate for dryland barley ranges from 30 to 70 pounds/acre planted in rows about seven inches apart. Growers apply fertilizer by broadcast or banding. Herbicide choices to control wild oat in spring barley include triallate (Fargo®), diclofop (Hoelon®), difenzoquat (Avenge®), or imazamethabenz (Assert®).

## ROW SPACING & SEEDING RATE

Idaho researchers have studied wild oat control with barley row spacings ranging from 3.5 inches to 15 inches. In one study comparing 8-inch and 15-inch spacings, there was no difference in wild oat density where nitrogen was banded between rows, but there were more wild oats with the wide row spacing where nitrogen was broadcast (Table 1). Wild oat control and barley yield were similar in another study comparing 3.5-inch and seven-inch spacings.
The researchers conclude that row spacing is not a predominant factor in wild oat control.

In contrast, barley seeding rate did influence weed control and grain yield (Figures 1 and 2). Barley grain yield increased with increasing seeding rate when no herbicide was applied. Wild oat biomass was reduced about 60 percent as seeding rate increased from 60 to 180 pounds/acre where herbicides were used. The highest seeding rate with no herbicide reduced wild oat biomass as much as the half-rate of herbicide applied in barley seeded at the lowest rate. Increased barley plant density reduced the grain yield loss due to wild oat and reduced the production of wild oat seed, a potential bonus for future years. Higher seeding rates led to more lodging and reduced grain quality. Percent thin barley kernels usually increased and test weight decreased as seeding rate increased. The optimum barley plant density for reduced wild oat competition and high quality barley was estimated to be 21 to 23 plants per square foot, or a seeding rate of 120 pounds/acre. This is 1.4 to 3.6 times more plants per unit area than used currently by most growers.

**TABLE 2**
**Net returns from different wild oat herbicide rates on spring barley, Bonners Ferry, Idaho.**

| Herbicide Rate | 1989 | 1990 |
|---|---|---|
| | —— dollars/acre —— | |
| None | 265b | 190b |
| Half | 375a | 210a |
| Full | 360a | 190b |

Numbers with the same letter in a column are not significantly different ($p<0.05$.)

## FERTILIZER PLACEMENT

Wild oat was more competitive when fertilizer nitrogen was broadcast instead of banded (Table 1). The Idaho researchers found that wild oat growing in banded nitrogen plots was

MORE WILD OAT, PAGE 3

The *Sustainable Farming Quarterly* is a publication of the Dryland Cereal/Legume Project, a USDA Sustainable Agriculture Research and Education (SARE) project, based at Washington State University.

The *SFQ* is published by the Alternative Energy Resources Organization, 44 N. Last Chance Gulch, Helena, MT 59601. (406) 443-7272.

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**Printed on recycled paper at Broadwater Printing Co., Townsend, Mont.**

**WILD OAT, FROM PAGE 2**

shorter and more yellow than in the broadcast plots. Wild oat density was lowest and plant height shortest where nitrogen was banded. Overall, light penetration through the barley was about 40 percent lower with broadcast nitrogen, compared to banded nitrogen. When wild oat was not present, fertilizer placement did not affect grain yield. But grain yield was 17 percent greater with banded nitrogen in the presence of wild oat.

## HERBICIDE USE

Three herbicides were used in a study of integrated wild oat control in spring barley: triallate (preplant), diclofop and difenzoquat (both postemerge). Each herbicide was applied at full and half label rates, and a non-herbicide control was included (Figures 1 and 2). Barley grain yield and test weight were greatest and grain quality highest when either the half or full rate of herbicide was used. Triallate was less effective in controlling wild oat than the other herbicides, but this did not always result in lower grain yield. There was more wild oat biomass with the half rate application compared to the full rate, but this did not result in significantly lower barley grain yields between the two treatments. Half rates of difenzoquat and diclofop provided 82 percent wild oat control compared to 94 percent control with the full rate in a related study.

**Figure 1. Effect of barley seeding rate and herbicide rate on wild oat biomass.**

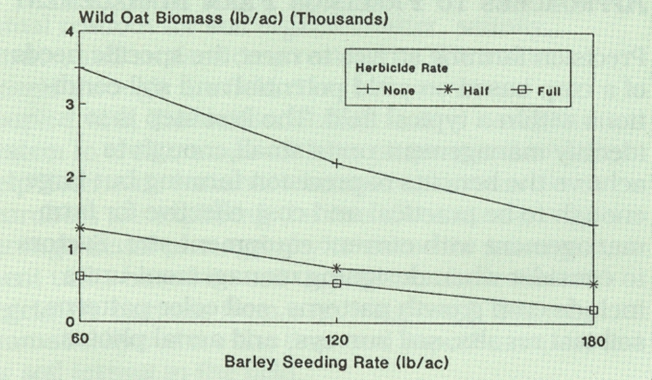
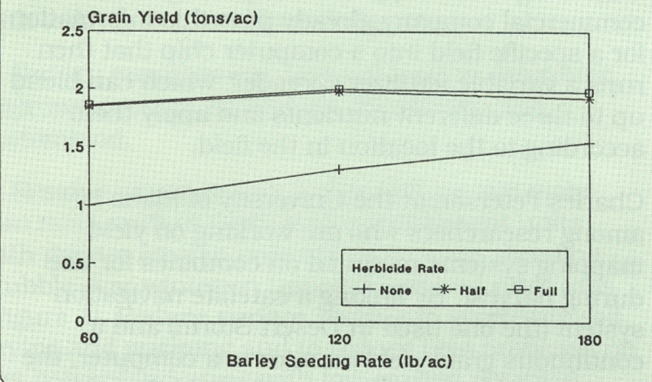



**Figure 2. Effect of barley seeding rate and herbicide rate on barley grain yield.**




## ECONOMICS

With all these results, Idaho researchers have calculated the estimated net returns from various integrated weed management approaches for wild oat in spring barley. In all cases, there was significant improvement in net returns using either a half or full herbicide rate (Table 2). The half rate herbicide treatment, regardless of barley seeding rate and type of herbicide, provided the highest average net return during both years of the study. The full rate often provided better wild oat control, and the economic impact of increased weed seed production needs to be considered. Increasing barley seeding rates from 60 to 120 to 180 pounds/acre can reduce wild oat competition and improve barley grain yield in the absence of wild oat herbicides. However, barley grain yield, quality, and net return were always highest when wild oat herbicides were used.

Thill and his Idaho associates are continuing their work on integrated weed control in barley. The bio-economic model will be field tested by select growers in spring 1993. They will be adding information on broadleaf weed control and weed seed levels to the bio-economic model to improve its predictive ability. But growers can benefit today from the model in tailoring weed management decisions in barley to the actual conditions in a field. This will lead to greater profits and lower herbicide loading of the environment.

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The Sustainable Farming Quarterly *will publish, at no cost, the dates of workshops, farm tours, and other activities of interest to our readers. Send them to* SFQ, *c/o Alternative Energy Resources Organization, 44 N. Last Chance Gulch, Helena, MT 59601. The deadline for the next issue is Dec. 1.*

**VARIABILITY, FROM PAGE 1**

wheat-pea rotation on the lower slopes to minimize erosion and maximize income.

Farmers have begun to experiment with variable management without the new high-tech tools. Some are using different cereal varieties to match disease or winterkill problems associated with certain landscape positions. Others spot-spray areas with significant weed problems rather than spraying a whole field.

Several farmers have used simple valve mechanisms to deliver variable fertilizer rates to hilltops versus bottomlands. Those farmers adopting divided slope farming to meet conservation compliance can use the divides to designate different management units for precision farming. Soon, tractor-mounted satellite navigation and GIS (geographic information systems) will be accurate enough, affordable and available to assist farmers in precision management.

## CAUSES OF VARIABILITY

Farmland soil is far from a uniform resource. There are natural variations in soil depth, organic matter, texture and pH across a field. These factors help determine potential crop productivity and the suitability of management techniques. Glacially-derived soils in the Northern Plains are highly variable in texture and soil fertility. Individual fields often contain multiple soil types, leading to significant variation in yield and profitability (Table 1).

In the steep Palouse hills, soil-forming processes and crop growth conditions differ on the moist, cool north-facing slopes compared to the warmer and drier south-facing slopes. In a recent study near Pullman, Wash., soft white winter wheat yields varied by more than 50 percent across four landscape positions in a field. Reduced yields on ridge tops and north-facing slopes were associated with reduced head density and lighter kernel weights. Test weights ranged from 53.8 to 61.7 pounds/bushel and grain protein ranged from 8.6 to 13.1 percent across landscape positions. Typically, eroded ridge tops had much lower test weights and higher grain protein content. In other studies, winter barley and dry pea yields declined 46 percent and 77 percent, respectively, from the bottomland to ridge tops.

**Table 1. Effect of soil type within a field on crop yield and net returns, Montana.**

| Location | Soil Unit | Yield bu/ac | Returns dollars/ac |
|---|---|---|---|
| Havre, barley recrop | Ke-Hi | 26 | - 6.78 |
| | Ev | 67 | 67.07 |
| | Ph | 35 | 9.93 |
| Havre, barley fallow | Te-Jo | 28 | - 1.26 |
| | Ge-Cr-Ab | 80 | 97.23 |
| | Ph-El | 40 | 20.86 |

SOURCE: CARR ET AL., 1991

Farming activities of the past century have induced landscape variability in addition to that provided by nature. Human-induced soil erosion has accentuated productivity differences on hilltops versus bottomlands. This includes tillage erosion — the downhill movement of soil due to mechanical turning of soil on sloping lands.

The use of ammonium-based fertilizers has significantly reduced soil pH in parts of many fields. Crop-fallow farming in certain parts of Montana has led to saline seep development, requiring drastic changes in land use.

## APPROACHES TO PRECISION FARM MANAGEMENT

Precision farming strives to meet the specific needs of a crop based on yield potential and soil conditions within a typical field. The first step is to identify management units small enough to achieve the benefits of precision farming but large enough to be practical and cost-effective for farm management with current equipment size. Factors to consider when designing management units include crop growth patterns, soil color patterns, soil test results, soil surveys, and aerial photos.

New computer tools are making this easier. For example, soil test data from a field sampled in a grid pattern can be entered into a GIS, and practical management units can then be delineated. One commercial company already puts this information for a specific field into a computer chip that then runs a variable fertilizer spreader, which can blend up to three different nutrients and apply them according to the location in the field.

Charles Peterson at the University of Idaho is among researchers who are working on yield mapping systems mounted on combines for use during harvest. By linking a satellite navigation system (the one used in Desert Storm) and a continuous grain yield monitor to a computer, the system generates yield maps of a field that show contour lines of different yields. Practical management units can be identified from this. A farmer can then apply precision management to the individual units and easily monitor the results by mapping the yield of future crops.

MORE VARIABLES, PAGE 5

VARIABLES, FROM PAGE 4

Continued advances in satellite navigation technology are expected to improve field location accuracy to a matter of feet. In addition, new tractor-mounted sensor technology is being developed to give continual readout for soil organic matter, salinity, nitrate, and surface crop residue as the tractor travels through the field. This information is coupled with the locational data from a navigation system to create maps of these properties that will help determine suitable management units. Researchers are exploring the use of remote sensing through aerial photography to delineate management units based on soil organic matter levels and vegetative biomass from a growing crop. This may dramatically reduce the time and expense required for soil testing in the field.

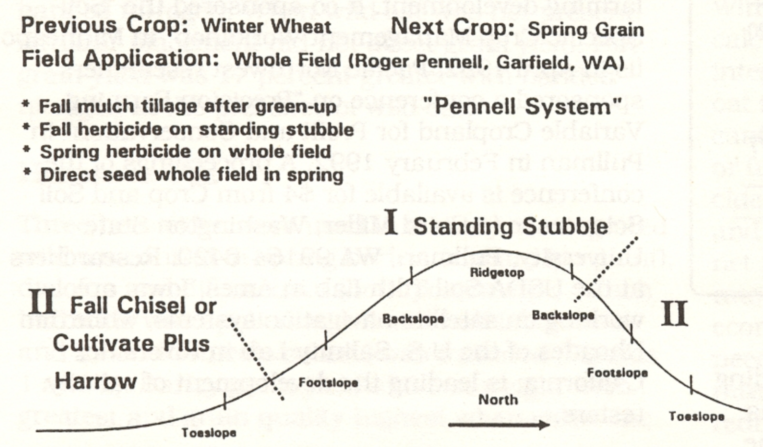


*Figure 1. Matching the tillage system to the erosion potential of different landscape positions. Source: Vaseth and Miller, 1992.*

Several examples of management options for variable cropland are listed below to illustrate that growers can begin implementing precision farming with today's tools and knowledge.

❐ *Fertility management*: Use soil tests to determine appropriate rates for hilltops, sideslopes, and bottomland.

❐ *Residue management*: Reduce tillage and maintain more surface residue on management units with greater erosion potential (e.g., leave standing stubble over winter on upper slopes and ridge tops (Figure 1). Reduce surface residue to accelerate soil drying and warming and to reduce pest problems on wet bottomland areas with low erosion potential (e.g., fall moldboard plowing).

❐ *Disease management*: Use longer crop rotations (wheat-barley-pea instead of wheat-pea) and disease-resistant varieties (Madsen, for strawbreaker foot rot) in disease-prone management units, such as bottomlands.

❐ *Weed management*: Match rate of soil active herbicides to the soil texture and organic matter of the management unit.

### PROMISING RESEARCH RESULTS

A field-scale study was conducted on two farms near Colfax, Wash., during 1987 and 1988 that determined soil properties every 50 feet along 2,000-foot transects through fields in a summer fallow-winter wheat cycle. Researchers David Mulla (Washington State University) and Max Hammond (CENEX/Land O'Lakes) then calculated the appropriate fertilizer rate for each sample site based on available water, available nitrogen, soil organic matter, and available phosphorus. They then created three management zones for each farm to be fertilized with specific nutrients and rates (Table 2). Their variably-fertilized strips were adjacent to strips uniformly fertilized by the grower. At harvest, yields were measured for the respective strips, and the variable rate showed a net economic benefit for both farms (Table 3). Mulla found that soil organic matter, phosphorus and nitrogen content, available water, yield potential and fertilizer requirement were generally closely correlated with landscape position and soil color. Thus, an easy property to measure, such as soil color from an aerial photo, could be used to determine management units for other properties.

**Table 2. Management units for variable fertilizer study near Colfax, Wash.**

| Management Unit | % of Transect Length | Fertilizer Rate (lb/acre) N | Fertilizer Rate (lb/acre) $P_2O_5$ |
|---|---|---|---|
| St. John site — | | | |
| Low N, low P | 38 | 20 | 12 |
| Medium/hi N, low P | 31 | 80 | 12 |
| Low N, hi P | 31 | 20 | 40 |
| Colfax Site — | | | |
| No fertilizer | 48 | 0 | 0 |
| Low N | 29 | 25 | 0 |
| Medium N | 23 | 50 | 0 |

Source: Veseth, 1989

After six years, researchers are reaping interesting results from an integrated pest management study near Pullman, Washington, focusing on dryland weed management. Three different slope positions are represented in the study, allowing comparison

MORE VARIABLES, PAGE 6

**Table 3. Comparison of variable versus uniform fertilizer application near Colfax, Wash.**

| Method | Wheat Yield (bu/ac) | Fertilizer Cost | Net Benefit |
|---|---|---|---|
| St. John — | | — $/acre — | |
| Variable | 63.5 | 18.95 | 11.20 |
| Uniform | 61.7 | 22.05 | — |
| Colfax — | | | |
| Variable | 57.7 | 2.58 | 31.77 |
| Uniform | 53.7 | 16.35 | — |

Source: Veseth, 1989

**VARIABLES, FROM PAGE 5**

of weed problems and control strategies according to landscape (Table 4). Weed pressure varied as much among landscape positions as among the three crops in the rotation. The lower weed pressure on the summit led to the highest return on weed control investment in winter wheat and peas by using the moderate weed management level, compared to better returns from maximum weed management at the bottom slope positions.

Chris Boerboom, extension weed scientist at Washington State University, cautions that variable weed management will have its own costs in terms of weed scouting and new sprayer equipment. Reduced herbicide costs may or may not be offset by

**Table 4. Variable soil and weed conditions across landscape position at the USDA IPM weed plots near Pullman, Wash.**

| | North Footslope | Summit | South Footslope |
|---|---|---|---|
| Soil pH | 5.6 | 5.6 | 5.6 |
| Soil organic matter % | 3.5 | 2.6 | 3.1 |
| Grass weeds (yd²) | 81 | 18 | 39 |
| Broadleaf weeds (yd²) | 183 | 61 | 119 |

*Average over the wheat-barley-pea rotation
Source: Veseth and Miller, 1992.

the added management and equipment costs. More data are needed on economic thresholds for weeds in the various parts of the dryland region. But growers who are applying a lower herbicide rate or avoiding certain herbicides on ridge tops are taking a first step towards variable weed management.

### RESOURCES FOR PRECISION FARMING

A number of resources, both people and paper, are available for growers interested in pursuing precision farming ideas. Montana State University soil scientist Jerry Nielsen has organized a network entitled Precision Land and Climate Evaluation Systems (PLACES). The network includes university and industry researchers involved in precision farming development. It co-sponsored the "Soil-Specific Crop Management Workshop" in Minneapolis in April 1992. Pacific Northwest researchers sponsored a conference on "Precision Farming Variable Cropland for Profit and Conservation" in Pullman in February 1992. A proceedings of the conference is available for $4 from Crop and Soil Sciences, c/o Baird Miller, Washington State University, Pullman, WA 99164-6420. Researchers at the USDA Soil Tilth Lab in Ames, Iowa, are working on satellite navigation systems, while Jim Rhoades of the U.S. Salinity Lab in Riverside, California, is leading the development of salinity testers.

Farmers can make use of the principles of precision farming without sophisticated satellite systems. The key is to identify meaningful management units, from soil tests, aerial photos, or experience, that will benefit from variable management and still be practical to farm. As in the past, grower innovation will undoubtedly be applied to variable landscape management. Many home-grown approaches will evolve to put the principles to work for profit and stewardship on Northwest dryland farms.

### FURTHER READING


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## DRYLAND FARMING RESOURCE GUIDE RELEASED

### "AMBER WAVES" IS A SUSTAINABILITY ROUNDUP

One of the primary objectives of the Northwest Dryland Cereal/Legume Cropping Systems project, funded by the USDA Sustainable Agriculture Research and Education (SARE) program, is to gather, interpret, and disseminate information on options for enhancing the sustainability of dryland farms.

To this end, project manager David Granatstein has spent the better part of a year developing a publication that summarizes research findings and information resources available to dryland farmers today. *Amber Waves: A Sourcebook for Sustainable Dryland Farming in the Northwestern United States* summarizes both historical and current research on the use of legumes in dryland cereal cropping systems, and also discusses moisture management strategies and the maintenance of soil quality.

This book is designed to fill an information gap regarding legumes and crop rotations, since other key issues such as erosion control and disease management are covered in existing references. The book ends with a resource guide to help lead people to further information. *Amber Waves* is intended for use by those familiar with dryland farming techniques.

While producing *Amber Waves*, Granatstein saw the need for another publication explaining dryland farming to those unfamiliar with it. Often, policymakers and environmental advocates from other parts of the country do not understand the unique challenges of dryland farming and tend to believe Corn Belt solutions work in all farming systems. Granatstein wrote Dryland *Farming in the Northwestern United States: A Nontechnical Overview* to explain the fundamentals of dryland farming to these audiences interested in sustainable agriculture.

These publications can be ordered from Cooperative Extension Bulletin Office, Cooper Publication Building, Washington State University, Pullman, WA 99164-5912. Copies of *Amber Waves* (XB1025) are free, while the overview (MISC0162) costs $1 per copy. For bulk orders to be used for agency or educational purposes, call David Granatstein at (509) 335-3491. ❐

## NEW "FOLIO VIEWS" PRESENTS SUSTAINABLE OPTIONS THROUGH COMPUTER PROGRAM

As part of the Sustainable Agriculture Network, a national information project funded by the USDA SARE (formerly LISA) program, Phil Rasmussen of Utah State University has uncovered a promising software package for delivering sustainable agriculture information.

The Folio Views program (Folio Corp., Provo, Utah) is a hypertext search system that is being coupled with information packages to provide fast, easily accessible database searches. No additional software is needed to run a search, one of the advantages of the Folio system. Rasmussen has coined the term "infobase" for the products he is developing.

Two infobase packages are now available. One contains project summaries for all USDA SARE funded projects and those funded under the joint USDA-EPA Agriculture in Concert with the Environment (ACE) program. The other package contains the Northwest Dryland Cereal/Legume Cropping Systems database that was formerly released by Washington State University Extension. With Folio Views, the database can be used on any IBM-compatible computer with no additional software. Rasmussen anticipates more of these "infobase" packages in the future. In addition, he has set up an electronic bulletin board for sustainable agriculture that is accessible by the public through a computer modem. To use it, call (801) 750-2195 with a computer that has standard ANSI-color emulation terminal software (e.g., PROCOMM).

For more information, contact Phil Rasmussen at the Department of Plant, Soil, and Biometeorology, Utah State University, Logan, UT 84322-4820; (801) 750-2255. ❐

# RESOURCES

*(The following list of resources is offered as a service to SFQ readers. The materials included are not necessarily endorsed by the SFQ or the Dryland Cereal/Legume Project.)*

**SYSTEMS OF WEED CONTROL IN WHEAT IN NORTH AMERICA.** 1992, Weed Science Society of America. $45. This comprehensive discussion of production practices by 26 weed scientists summarizes methods and research on weed control in wheat from 1945-1989. The 487-page, 22-chapter book describes weeds commonly found in wheat fields and their yield loss assessment; a review of wheat production practices and weed control systems for the Pacific Northwest and nine other regions, and a review of herbicides used in wheat, including application methods, spray additives, crop responses, and environmental effects. Call (217) 356-3182 or write WSSA, 309 West Clark St., Champaign, IL 61820.

**CROP RESIDUE MANAGEMENT FOR CONSERVATION.** 1992, Soil and Water Conservation Society, $10 postpaid. This is the proceedings of a conference held in Lexington, Ky., in August of 1991. It provides a concise, region-by-region discussion of the science and art of crop residue managment by experts in the government, academic, farm, and business communities, including views from the Soil Conservation Service and Extension Service. Write Soil and Water Conservation Society, 7575 Northeast Ankeny Road, Ankeny, IA 50021-9764; or call toll-free (800) THE-SOIL or (515) 289-1227 fax.

**FENCES FOR PASTURE AND GARDEN.** By small-scale farmer and freelance writer Gail Damerow of Tennessee, $16.90 postpaid. The book weighs the pros and cons of various fences and offers solutions to common fence-building obstacles, such as rugged terrain and severe weather. $16.90 postpaid. Call (800) 827-8673 or order from Storey Communications, Inc., P.O. Box 445, Pownal, VT 05261. ❒

## AT LAST: A COMPREHENSIVE CALENDAR OF SUSTAINABLE AG EVENTS NATIONWIDE

The Alternative Farming Systems Information Center of the National Agricultural Library in Beltsville, Maryland, is now keeping a nationwide calendar of events related to sustainable agriculture. Conferences, field days, and workshops are listed and the calendar is continually updated.

To add items to the calendar, or to request a copy, write to AFS Calendar, Room 304, National Agricultural Library, 10301 Baltimore Blvd., Beltsville, MD 20705-2351, or call (301) 344-3724. ❒

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