

# SUSTAINABLE FARMING

## Quarterly



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### Synthetic nitrogen application

**New research shows that the point of diminishing returns is reached much sooner than has been widely believed**

*By Sally K. Hilander, SFQ editor*

Large amounts of synthetic nitrogen fertilizers are routinely used in wheat-legume rotations in northern Idaho and eastern Washington to achieve maximum wheat yields, but new research shows that over-fertilization is expensive, inefficient, and a potential threat to water quality

Nitrogen-use efficiency has received increased attention due to these concerns. Dr. Robert Mahler, a soil scientist at the University of Idaho, for example, is developing a comprehensive database on winter wheat response to nitrogen application rates, and evaluating the potential of crop residues from legumes and wheat as nitrogen sources for the following crop.

This study, supported in part by the six-state Dryland Cereal/Legume Project, will continue during the 1991 growing season.

Past research within the region has indicated a crop requirement of 2.7 pounds of nitrogen (from all

#### Inside the SFQ...

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sources) per bushel of wheat, assuming fertilizer use efficiency to be 50 percent, Mahler said in a May 1990 interim report on the

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### Legumes in rotation work well if moisture can be conserved

*By David Granatstein, project coordinator for the six-state Dryland Cereal/Legume Project.*

Dryland cereal cropping has been extensively studied for decades in the Canadian prairie provinces, and the results are summarized in a practical and readable publication useful on both sides of the border.

Scientists from Saskatchewan have produced *Soil Improvement with Legumes*, a 42-page booklet filled with information and color photos and released by the Soils and Crops Branch of Saskatchewan Agriculture in Regina. Parts of Saskatchewan and Alberta are similar agroclimatically to many Montana and North Dakota wheat areas.

In Canada, forage and grain legumes were used to provide nitrogen prior to the advent of commercial fertilizers, but were frequently found to depress subsequent grain yields due to soil moisture depletion. Yet the widespread use of a wheat-fallow system in Saskatchewan has led to extensive soil degradation via increased erosion and salinity. Soil organic matter levels decreased 40 to 50 percent during the first 70 years of cultivation. This parallels what many long-term U.S. studies have found.

The use of legumes in rotation can help restore favorable physical, chemical and biological soil conditions by enhancing nitrogen-supplying power, reducing wind and water erosion, improving soil

structure, aeration, and water-holding capacity, and providing for easier tillage.

Deep-rooted perennial legumes, such as alfalfa, have the greatest effect. Six successive wheat crops after an alfalfa crop yielded 80 to 90 percent more than the same crops after fallow on degraded Alberta soil, according to the report. A three-year sweet clover rotation without fertilizer yielded more total grain than a three-year fallow rotation with fertilizer over a period of 17 years in Saskatchewan. (See Table 1, page 2.)

Legumes not only add nitrogen, but can bring up phosphorus and other nutrients from the subsoil and increase their availability to

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the plant. Soil aggregation often improves due to the stimulating effect of a legume green manure on the soil microbes. This can translate into a measurable reduction in machine power requirements (See Table 2).

proper Rhizobium strain is normally recommended, and is necessary if the particular legume (or others that use the same Rhizobium strain) has never been grown on a specific field before. Rhizobium can persist in soils for many years without the

root systems, such as red clover, improve topsoil tilth.

In summary, legumes can play an important role in soil improvement. There are trade-offs in their use in dryland farming, particularly in relation to water use.

**Table 1. Effect of sweetclover green manure on wheat yields at Indianhead, Sask., 1960-76.**

Rotation	Average yields (bu/ac)	
	1st year wheat	2nd year wheat
Wheat-wheat/clover-clover	37.5	38.6
Wheat-wheat-fallow	33.4	17.4
Wheat-wheat-fallow (fertilized)	37.7	24.7

To realize the greatest benefit from legumes, proper fertility conditions are needed. Legumes will preferentially use nitrogen from the soil rather than fix nitrogen when the level of available soil nitrogen is high (more than 45 pounds per acre). Thus, a legume is most effective for increasing soil nitrogen when following a high-nitrogen-using crop.

On soils with very low levels of nitrogen, the addition of 10 to 15 pounds of starter nitrogen fertilizer per acre on a legume crop can boost seedling growth prior to nodulation. Applications of fertilizer nitrogen at rates greater than 25 pounds per acre can substantially reduce nodulation and inhibit nitrogen fixation. Legumes in general require ample amounts of phosphorus, calcium and sulfur for proper growth. Also, the trace element molybdenum is necessary for active nitrogen fixation.

Inoculation of the seed with the

legume host, but may not be effective due to low numbers or poor competitiveness.

Rhizobium are sensitive to low soil pH, and many strains will die below pH 5.5. Acid-tolerant strains are being selected for better survival and nodulation. Fungicidal seed treatments, particularly captan, can kill seed-applied Rhizobium if the pre-plant contact time is more than one or two hours.

The majority of legume nitrogen is in the top growth, and thus any crop removal for seed or forage will reduce the nitrogen contribution to the soil. Forage legumes (those either grazed or harvested as hay) have considerably more root biomass than grain legumes (those harvested for seed), and can thus still contribute to soil improvement, despite forage removal. Species with strong tap roots, such as alfalfa and sweet clover, are effective in reversing deep compaction, while those with fibrous

Current research in the U.S. and Canada is looking at water use by a number of legumes, and the net effect on cereal crop production. One strategy is to work the legume under after it has used a predetermined amount of moisture. The potential nitrogen and soil structural benefits of legumes are well-documented. Less understood are the positive "rotation effects" that boost subsequent yields beyond any apparent fertility contributions.

**Table 2. Tillage power requirements (6-inch depth) with and without legumes in rotation, Saskatchewan.**

Location	Power requirement (ft/lb)	
	Legume	No legume
Scott	139	215
Loon Lake	96	173
Melfort	478	638
Indianhead *	254	229

\*Difference not significant.

Soil improvement can also be achieved with cropping systems that do not include legumes. But the wide choice of species, production options, potential economic yield, and available information, makes legumes a worthwhile consideration for many growers.

**NITROGEN, from page 1**

project. This relationship has not been examined under today's management practices and cereal varieties. In addition, the nitrogen value of various crop residues to a following wheat crop are not well quantified under current cropping practices, Mahler noted.

To develop the database on winter wheat response to nitrogen application rates, Mahler conducted two sets of field trials east of Moscow during 1988 and 1989 to determine the amount of nitrogen per bushel required to reach optimum nitrogen use efficiency. He compared 41 nitrogen fertilization treatments ranging from zero to 200 pounds per acre in five-pound increments. He examined the effect of the various application rates on wheat yield, nitrogen use efficiency and nitrogen optimization.

The optimum amount of nitrogen to produce a bushel of wheat was computed from the initial soil test nitrogen (51 pounds per acre), mineralizable nitrogen (50 pounds per acre) and the initial fertilizer application rates.

Nitrogen use efficiency was slightly greater than 50 percent at nitrogen fertilizer rates of less than 95 pounds per acre, and efficiency dropped off rapidly at rates above that, the report says. At the highest application rates, nitrogen use efficiency was less than 30 percent. The excess applied nitrogen was probably leached below the root zone, or lost through denitrification.

The study concluded it takes 2.75 pounds of nitrogen to produce each bushel of winter wheat. This is the same amount predicted in the mid-1950s by Glen Leggett, a Washington state researcher, so apparently this requirement has not changed for

the modern semi-dwarf wheat varieties. "Clearly, over-fertilization does not pay," Mahler said. "However, meager rates of nitrogen (less than 30 pounds per acre) do not necessarily result in more efficient use of nitrogen by wheat plants."

The data from this study may allow researchers to optimize nitrogen use efficiency, Mahler said, and the information can be used by economists to design farm production models employing reduced input concepts.

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*University of Idaho Fertilizer Guidelines* suggest a total nitrogen application of 90 pounds per acre as optimum. "This means that current recommendations made by the University maximize nitrogen use efficiency and economic return for local growers," Mahler said. The next logical step, he said, is to find more economical sources of nitrogen and the answers may be in modifying crop rotations. But if nitrogen rate applications are restricted in the future, Mahler hopes his data will help growers most effectively allocate their fertilizer.

To evaluate the effect and potential of crop residues as nitrogen sources for a wheat crop, studies were initiated by Mahler in 1987 for winter wheat and in 1989 for spring wheat east of Moscow, Idaho. Plant residues were used as the sole nitrogen source for the wheat crops that followed.

Residue materials included pea,

alfalfa and green wheat straw, surface applied and incorporated at rates of 1,000 pounds per acre, 2,000 pounds per acre, and 3,000 pounds per acre, at least 30 days prior to the wheat seeding. Check plots received no residues. Data included wheat yield, inorganic soil nitrogen information, and nitrogen values for each residue treatment.

Pea residue supplied 28 to 29 pounds of nitrogen per 1,000 pounds of residue per acre to the following wheat crop. Alfalfa residue provided 30 to 31 pounds of nitrogen, and the green wheat straw residue contained 19 to 20 pounds. But Mahler said the nitrogen from the wheat straw apparently was not available to the succeeding wheat crop.

Both the pea and alfalfa residues resulted in increased winter wheat yields when compared to the check plots. "In general, the higher the residue rate, the higher the yield increase," Mahler said. The wheat straw residue did not improve winter wheat yields over the check plots.

The three residues tested also had significant effects on the 1989 spring wheat crop, Mahler reported. In general, pea residue treatments outperformed alfalfa and wheat-straw treatments, perhaps because the nitrogen from the pea residue was mineralized faster than nitrogen from corresponding alfalfa residue treatments.

When the yield data from the winter and spring wheat studies were combined, it was apparent both residue source and rate had a significant impact on cereal yields. The 3,000-pound-per-acre application of pea residue resulted in greatest cereal yields. Finally, the rotation itself provides some unexplained benefit in addition to the nitrogen added.

# Farm tours reveal grower innovations

*No recipes, but many ideas are on the front burner*

*By David Granatstein, project coordinator for the six-state Dryland Cereal/Legume Project.*

That every farm requires a unique blend of management approaches was underscored during summer tours of six dryland farms in eastern Washington and northern Idaho, attended by growers, researchers and agricultural agency representatives.

No simple solutions were offered for economic and environmental concerns, but successful alternative practices and integrated farm systems were viewed by the tour groups and described by the host growers.

The tours were sponsored by the Progressive Farmers Inland Northwest (PFIN) in cooperation with Washington and Idaho Extension.

May 24 tours included three farms in the Dayton-Walla Walla area of southeastern Washington, where rainfall ranges from 16 to 24 inches per year.

## **Grass key to moisture retention**

Long-term grass is a key ingredient in Eric Thorn's plan for conserving every bit of soil and moisture on his steeply-rolling land near Dayton. Each field goes through a perennial grass phase in the rotation (from 5 to 30 years, depending on the ground) and then it is cropped to wheat and peas for several decades.

Thorn has continued this prac-

tice, which his father started due to its effective erosion control.

One third of the grass produces an economic return as seed or forage in any given year. The rest is considered a necessary investment in the land — an expensive investment when cash costs, lost income and penalties to acreage base under the farm programs are included.

## **Mechanical "pits" stop erosion**

Jack DeWitt has managed to control erosion on his steep slopes with a dammer-diker tillage implement pulled through winter wheat just after planting. It subsoils the ground and leaves "pits" in the surface to trap water and sediment.

In the spring of 1989, after an erosive winter, no erosion was evident on a 40 percent slope tilled the previous fall with the dammer-diker, according to DeWitt.

The implement does require much power to pull, and it can reduce the wheat stand. Recent field results, however, show wheat yields with the dammer-diker to be equal to or greater than a number of other planter-tillage systems commonly used.

## **Organic matter made on the spot**

Ron Klassen uses a subsoiler-ridger tool to deeply fracture the soil and mound it over the shank marks, thus improving water infiltration while "composting" the crop residues. Soil tests over the past four years on eight fields

show steadily increasing soil organic matter levels. Klassen also has seen a decrease in footrot disease and a dramatic increase in the effectiveness of Fargo and Sencor herbicides.

The subsoiler-ridger implement comes from the Midwest and was introduced to the Pacific Northwest by another Walla Walla farmer who was concerned about compaction, water infiltration and residue breakdown.

Participants on a second tour June 18 visited two farms near Lewiston, Idaho, both of which use green manures in their rotations:

## **Wheat yields up after buckwheat**

The Gary Schwank farm (18-22" inch rainfall) has substituted buckwheat for dry peas in the rotation. Schwank's ideal rotation is winter wheat followed by buckwheat harvested for seed, followed by winter wheat, followed by buckwheat grown as a green manure.

The cash cost for the buckwheat is about \$35 per acre. The buckwheat is a good nutrient scavenger and so receives no added fertilizer.

Schwank has seen winter wheat after buckwheat green manure yield from 16 to 60 bushels per acre more than adjacent fields without the green manure. He attributes some of this effect to a slow release of nitrogen to the crop from the decomposing buckwheat.

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## Beating the high cost of purchased inputs

# Farmer learns value of legumes in continuous cropping

*Compiled by SFQ Editor Sally K. Hilander from interviews conducted by Washington State University in 1989, and by the SFQ in August of 1990.*

OAKESDALE, WASH. — Dennis Pittman became a believer in using crop rotations that include legumes to improve soil fertility and control weeds in 1983. That was the year he saved \$20,000 over the previous year by reducing use of synthetic fertilizers and pesticides on the 2,200 acres of grain he and his family farm on the Palouse prairie of eastern Washington.

His bill for purchased inputs dropped steadily from a 1982 peak of \$120,000 to \$85,000 in 1989. Most of the savings Pittman attributes to reduced synthetic fertilizer use coupled with barley rotations that indirectly control cheat grass and wild oats, and so are a partial substitute for herbicides.

In 1989, Pittman planted some of his former federal set-aside ground into spring barley to launch a four-year rotation on 400 acres in an effort to control cheat grass. Since cheat grass comes up in winter and late fall, breaking the ground to plant the spring barley interrupts the continuous wheat-lentil cycle that allowed the cheat grass to flourish. "The barley really cleans that stuff up," he said.

The four-year rotation begins with one year of winter wheat and is followed by two years of spring malting barley, followed by Columbia green peas and then back to winter wheat the fifth year. "I really like this rotation, but I might change it a little in

1991 to a three-year rotation: winter wheat to malting barley followed by peas, and then back to winter wheat," Pittman said. "I've talked to quite a few people who don't think two years of spring barley in a row will do that much good — although I've had good yield with them."

Pittman's seeding rates are 80 to 85 pounds an acre on the winter wheat, 90 pounds per acre on



barley, 180 pounds per acre on peas, and about 80 pounds on Brewer lentils, a new variety that Pittman said has taken over the lentil market on the Palouse. Brewers tend to mature earlier and yield more than the Chilean variety. His wheat is mostly Stephens.

The remaining acres will be peas, lentils, wheat and barley. He still plants lentils on extra spring ground that isn't on the three-year rotation because he doesn't

want too many acres of peas. But the lentils are not a good money-maker and peas fix more nitrogen. The price of peas this year is "an unheard of high" of 11 cents a pound. Most of the lentils and peas grown in the area are exported to foreign countries because there is not a big domestic demand.

Pittman described his farm as "bad wild oat ground." But with the described rotation, he's used little Hoelon, spot spraying only part of his wheat the last four or five years as opposed to all of it with the former wheat-pea rotation. "There was no question or doubt you'd Far-Go on spring crops every year and you used more Hoelon on the wheat crop every year, solid. You didn't even try to just hit patches or anything."

Other pesticide use includes Cygon and parathion for pea leaf weevil and for green aphids on lentils, but Pittman says he has generally become less concerned about insects.

Pittman's peak year for fertilizer use was 1982, when he applied 100 to 110 pounds of nitrogen per acre to the winter wheat. With the described rotation, he has reduced his application of purchased nitrogen to about 64 pounds of nitrogen per acre for the whole year on his winter wheat. The barley fertilizer application includes 60 pounds of nitrogen and 20 pounds of sulphur, impregnated with Far-Go for oat control.

Pittman uses no fertilizer on the pea crop following barley, and

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the need for weed control is minimal. "We've been getting awful clean lentil and pea crops off it. It's just amazing. We can't believe it."

Initially, Pittman said, the high price of purchased inputs, which peaked in the mid-1980s, motivated him to cut back. "You can see how long it took me to get brave enough to really make the cut. It was basically economics that started the whole thing, just trying to cut back somewhere." He was paying more and more for inputs, but wasn't realizing higher yields.

Pittman is president of Progressive Farmers Inland Northwest (PFIN), formed in 1988 in response to economic and regulatory pressures, and erosion and water quality concerns.

"If you're using less (chemicals), maybe the crop is using more of what you're putting out there, and there's less to leach. I'm hoping that anyway," Pittman said.

He said the goal of PFIN is to encourage farmers, environmental groups, and researchers to work toward common sustainable agriculture goals, and to initiate research on new techniques of farming. "We're developing a very good understanding after a year and a half," Pittman said, and membership has grown to 40 paid members and another 60 diverse readers on the mailing list.

Pittman's farm is in an 18-inch average rainfall area but moisture has averaged only 13.75 inches annually since 1987. Despite the dry conditions, however, Pittman is harvesting good crops and does not believe moisture is a major limiting factor.

Pittman's wheat yield following summer fallow averaged about 91 bushels/acre for 1987-1989, with 108 the highest. Following peas, wheat yields were 78 bushels in 1984, 72 in 1986 and 71 in 1988. Typically, wheat yields are five to eight bushels an acre more after peas than after lentils, Pittman said.

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**"I want to get back into managing the farm again instead of having the government manage it for me."**

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Over the past seven years (1982-1989), Pittman averaged a ton and a half of barley per acre, varying from a low of 2,600 pounds to a high of 3,700 pounds. And he's averaged \$24 a ton premium for the malting barley over and above the average price of \$68 to \$72 a ton for feed barley. He sells it through Oakesdale Grain Growers on the open market.

Pittman is not enamored of government farm programs and chose not to participate in 1989 or 1990. He hasn't yet made a decision about 1991. "I want to

get back into managing the farm again instead of having the government manage it for me. I lost a fair amount of money in 1988 by being in the (set-aside) program. If I would have had everything seeded, I would have made quite a bit more money."

In 1984, Pittman's wheat was hit with *Cercospora* disease. He averaged 34 bushels per acre on the recropped wheat-lentil-wheat ground, and on the other half of the same field, on the ground under barley rotation, he averaged 85 to 90 bushels of wheat. "The federal crop insurance officials couldn't believe it. They said it's just phenomenal. Of course, I didn't collect" because of the excellent yield in the same field.

After that experience, Pittman dropped the insurance. "There are just so many loopholes in that thing. It just doesn't pay as far as I'm concerned. You've got to have a complete disaster to ever collect."

Pittman's farm is rented from eight landlords. His parents, Laverne and Ruth Pittman, have lived on the farm for 46 years and are still actively involved with Pittman, his wife Carol, and their teen-agers, Brad and Kelli.

## **SFQ will continue to publish**

The June issue of the Sustainable Farming Quarterly included a readership survey to determine if the publication is meeting its goals after a year of publication. The response was positive and due to the renewal of the six-state Dryland/Cereal Legume Project, the SFQ will continue to publish at least until 1992.

Readers are encouraged to submit articles, suggested topics for articles, and notices of events related to sustainable agriculture. Send them to Sally K. Hilander, Sustainable Farming Quarterly, 44 N. Last Chance Gulch, Helena, MT 59624, or call her at (406) 442-8396.

## CALENDAR

### October

1-5: Northern Rocky Mountain Water Congress, Copper King Inn, Butte, Mont. Sponsored by the Montana Bureau of Mines and Geology, includes a Montana Symposium on Agrichemicals in Groundwater. Call Marvin Miller at (406) 496-4155.

9-10: International Sustainable Agriculture Symposium, Agri-center International, Memphis, Tenn. Call Ernest Shea at (202) 547-6223.

12: Cover Crops and Green Manure Workshop, St. Ignatius, Mont. for farmers and researchers. Call the Alternative Energy Resources Organization at (406) 443-7272.

13-14: AERO Annual Meeting, Moiese, Mont. Topics include the transition into sustainable agri-

culture. For more information, or to register, call (406) 443-7272.

14-17: Symposium on the role of farmers in farming systems research/Extension and sustainable agriculture, Holiday Inn, University Place, East Lansing, Mich. Call (517) 353-5262.

### November

14-16: New Ideas for Sustaining Farm Profits, North Platte, Neb. Workshop sponsored by the Center for Holistic Resource Management, 800 Rio Grand Blvd. NW, Suite 12, Albuquerque, NM 87104. (505) 242-9272.

### December

6-8: Livestock Health and Nutrition Alternatives Conference, Holiday Inn, Bozeman, Mont. Call AERO at (406) 443-7272.

## *Livestock conference set for December*

Registration is now open for Dec. 6-8 western states conference titled "Livestock Health and Nutrition Alternatives" in Bozeman, Mont.

Sponsored by the Alternative Energy Resources Organization (AERO), the conference will acquaint participants with management practices and technologies for raising healthy, profitable animals, while reducing the need for growth hormones, antibiotics and other purchased inputs.

The keynote speaker is Dr. Frank Baker of the Winrock International Institute for Agricultural Development in Morrilton, Ark. More than a dozen scientists,

ranchers, farmers and veterinarians will share their knowledge in panel and round table discussions.

Topics include alternative management practices that enhance growth potential, profitability, and efficiency of production through the "four phases."

Participants will explore disease prevention and health maintenance, use of probiotics, age at castration, crossbreeding, selective breeding, terminal cross concepts, slaughter times, feed additives, and timing of breeding, birthing and weaning.

For more information, call AERO at (406) 443-7272.

### TOURS, from page 4

#### **Five-year rotation includes a green manure crop**

Richard Grant plants a green manure every fifth year in his 20-24" rainfall area. His typical rotation is winter wheat to spring peas, to winter wheat to spring peas or spring barley underseeded with sweet clover and red clover, followed by clover green manure.

He has moved more to red clover because insects and disease have seriously reduced his stands of sweet clover and alfalfa. The clover is established during normal seeding of peas or barley.

Grant is exploring the nitrogen value of the green manure to determine the potential fertilizer reductions. One test showed that he added 65 pounds an acre more nitrogen fertilizer than the crop needed following the green manure clover. The clover also appears to eliminate the need for fungicide on the subsequent wheat crop, whereas Grant routinely applies Benlate fungicide on wheat after peas.

Innovations by farmers like these can help keep them ahead of the changing times in agriculture. Progressive Farmers Inland Northwest (PFIN) hopes to provide for more exchange among growers, and between growers and researchers, to sustain the farm productivity and profitability.

PFIN can be contacted at Route 4, Box 236, Walla Walla, WA 99362.

# RESOURCES

## ***Protecting Groundwater from Agricultural Chemicals: Alternative Strategies for Northwest Producers.***

By Christine Kaufmann and Nancy Matheson. Newly released by the Alternative Energy Resources Organization (AERO), this paper focuses on long-term prevention of pest and soil problems and ways to enhance the natural processes that keep pest populations in check and soil healthy. Specific examples of cultivation and seeding practices, crop rotations, biological controls, harvesting techniques, and intercropping, for instance, are used throughout the book to illustrate how common production problems can be minimized or prevented. To order, send \$4 to AERO, 44 N. Last Chance Gulch, Helena, MT 59624.

**Cover Crops Manual.** The 1989 Sustainable Agriculture Research and Education Program report was prepared by the University of California for the California State Water Resources Control Board. Applicable to the inland Pacific Northwest and Canada, the book explains the use of cover crops to retard soil erosion, improve tilth and water infiltration, furnish nutrients and provide habitat to beneficial insects. In many of

these roles, cover crops can reduce the need for synthetic fertilizers and pesticides, thereby improving and protecting surface and ground water. Included is information on dozens of plant species for use as cover crops, green manures and living mulches. Write the University of California Sustainable Ag Research and Education Program, University of California, Davis, CA 95616, or call (916) 752-7557.

## ***Farming for Profit and Stewardship Conference Proceedings .***

This edited transcript of the 1989 conference in Post Falls, Idaho, is a 70-page book containing talks given by more than 30 growers, researchers, policy makers and industry representatives. The conference focused on issues related to dryland and irrigated farming in the Pacific Northwest. Send a check for \$4 to the Department of Agronomy and Soils, Washington State University, Pullman, WA 99164-6420.

## ***Fertile Soil: A Grower's Guide to Organic and Inorganic Fertilizers.***

Due to be released Oct. 1 by agAccess, this book is useful to farmers, extension agents, and researchers. It contains hard-to-find information about soil fertility, fertilizer composition and use, and crop nu-

trient requirements. *Fertile Soil* is a complete reference on using animal manures and organic materials such as straw, compost and cover crops, as well as many different types of fertilizers and soil amendments. Call agAccess at (916) 756-7177.

## ***Guide to Crop Protection in Alberta.***

One of the best guides to Integrated Pest Management available. Farmers in the Northwest dryland region interested in non-chemical control methods for weeds, insects and diseases will find this publication indispensable. It describes the life cycles of various pests, plus the proper crop selection, cultural practices and rotations for controlling weeds and diseases. Turn to the section on quack grass, for example, and learn that buried seed can become dormant, that seed remains viable in the soil for up to four years, and that its seed is a contaminant of forage grass seed. Unlike other perennials, quack grass has no weak phase, so control is difficult. Methods include tillage, rotations, seeding spring crops early, and repeated mowing. Barley and fall rye provide good annual crop competition. Write Print Media Branch, Alberta Agriculture, 7000 113 Street, Edmonton, Alberta, Canada T6H 5T6.

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