

Minnesota/Wisconsin

Engineering Notes

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Machinery Systems

Combine Adjustments to Reduce Dry Bean Seed Damage

Tim Harrigan, Michigan Extension Engineer

Dry bean seed coats are easily damaged in harvest with most damage generally occurring during combine threshing process. Cracked and broken beans can be removed at a cost to the producer, but beans with checked seed coats are not easily removed and show poor quality characteristics in processing.

Specialty combines for dry beans are available, but most growers prefer to use a general-purpose combine suitable for other crops in their rotation. John Smith at the University of Nebraska recently evaluated adjustment and operation of the Deere 9000 series combine in an effort to minimize harvest damage to Great Northern, Light Red Kidney and Pinto beans. Here is a checklist of his findings:

- *Cylinder bar design*—Standard, hardened cylinder bars caused less seed damage than alternating smooth and standard bars or all smooth bars.
- *Cylinder speed*—An optional cylinder slow-down kit allowed a cylinder speed as low as 140 rpm at full throttle. Seed damage decreased with decreasing cylinder speed from 240 to 140 rpm.
- *Concave clearance*—A broad range of mid-range settings could be used without causing seed damage. Damage increased at the fully closed and nearly fully open positions.

- *Wires in the concave*—Seed damage was inconsistent and varied with site with all wires in place, half of the wires removed, or all wires removed.
- *Rotational speed of the clean grain conveyance system*—At the standard speed of 400 rpm the augers and elevator were at less than half capacity and beans flew from the end of the loading auger. Speeds of 180 to 250 rpm allowed beans to drop gently from the end of the grain tank loading auger.

Crop Drying & Storage

Reconditioning Overdry Soybeans

Bill Wilcke, Minnesota Extension Engineer
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 Biosystems and Agricultural Engineering Department

Why consider reconditioning soybeans?

Large portions of the upper Midwest have experienced exceptionally good drying conditions this fall and many soybeans have been harvested at well under 13% moisture (wet basis). The moisture content normally used for trading soybeans is 13%. When soybeans are sold at less than 13% moisture, sellers lose potential income because they could have sold additional weight if the soybeans had been closer to 13%. This situation creates an economic incentive for sellers to recondition overdry soybeans to increase their moisture content.

Is it legal to recondition dry soybeans?

It is definitely illegal to add liquid water to any grain or oilseed to increase moisture content (and weight) prior to sale. But federal agencies have indicated that aerating crops during humid weather to maintain or improve crop quality is not illegal.

Will soybeans gain moisture if they are aerated during humid weather?

Yes, given enough time and a high enough airflow per bushel (cubic feet of air per minute per bushel of beans, or cfm/bu),

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it is possible to increase the moisture content of soybeans by aerating them with humid air. But here are some practical concerns and limitations:

- The process is quite slow—even with the high airflow per bushel (0.75 to 1.0 cfm/bu) available on bins that are normally used for drying. It is possible, but very time consuming, to recondition soybeans by using the low airflow aeration systems common on storage bins.
- Fan control is tricky and some beans could end up too wet for safe storage.
- You will end up with layers of wet beans and layers of dry beans unless you can find some way to remove the wet layers or to mix the wet and dry layers.
- Swelling that accompanies rewetting will increase stress on bin walls and could potentially damage bins.

Is reconditioning economically feasible?

If the fan is controlled so that it only operates during rewetting conditions and if systems with moderate fan power and moderate airflow per bushel are selected, the value of the weight gain should exceed the cost of the electricity to run the fan.

How does the rewetting process work?

Table 1 shows the moisture content that soybeans would come to if exposed to different combinations of temperature and relative humidity for long periods of time. If you continuously aerated a bin of beans, they would tend to lose moisture during periods of low humidity and tend to gain moisture during periods of high humidity. To recondition soybeans, for example to 13% moisture, during normal fall temperatures of 30 to 60°F, you would want to control the fan so that it operates during weather that has an average relative humidity of 65 to 70%.

Note that the recommended moisture for beans that will be stored through winter is 13%. Beans that will be stored into the following summer should be about 12% moisture and beans that will be stored a year or more should be about 11% moisture. Table 1 indicates that bean moisture increases sharply as relative humidity increases, which means that it is quite easy to recondition soybeans to a moisture content that is too high for safe storage.

During reconditioning, the moisture of the whole bin doesn't change at once. A rewetting zone develops and moves slowly through the bin in the direction that the airflow is moving. This is similar to the way a drying zone moves through a drying bin. In most cases, there are not enough high humidity hours available in the fall to move a rewetting zone all the way through the bin. And in many cases, depending on how the fan is controlled, the parts of the bin that have been rewet will be too wet for safe storage. To avoid problems with spoilage or marketing of beans that are wetter than 13% moisture:

Table 1. Equilibrium moisture values (percent wet basis) for soybeans.

Temperature (F)	Relative Humidity (%)				
	50	60	70	80	90
32	10.0	11.8	13.7	16.2	19.8
40	9.8	11.5	13.5	16.0	19.6
50	9.5	11.2	13.2	15.7	19.4
60	9.2	11.0	13.0	15.4	19.1
70	8.9	10.7	12.7	15.2	18.9
80	8.6	10.4	12.5	15.0	18.7

- Mix the wet layers with the dry layers. Mixing can be accomplished to a limited extent by emptying the bin and moving the beans through a grain handling system. The most effective way to mix the beans, though, would be to use an in-bin stirring system. In fact, bin dryers equipped with stirring augers are a good choice for reconditioning soybeans.
- Remove wet layers from the bin as they reach 13% moisture. If reconditioning is done in a bin where air is pushed up through the beans, wet beans will be at the bottom of the bin and bean removal could be accomplished by using a tapered sweep auger that is permanently installed at the bottom of the bin. (This is the type of sweep auger used in continuous-flow bin dryers.) If reconditioning is done in a bin where air is pulled down through the beans, wet beans will be at the top of the bin and they could be removed from the top by using a vacuum-type grain conveyor, or they could be unloaded through the bin's center unloading sump.
- You can also avoid excessive rewetting by using a fan controller that turns the fan off during very humid weather. This option, however, will greatly limit the amount of reconditioning that can be accomplished because the fan will turn off during the best rewetting conditions.

How should the fan be controlled during reconditioning?

If the initial moisture content of the beans is 10% or less, controlling the fan so that it only runs when relative humidity of the air reaching the beans is greater than about 60% should result in rewetting. If you use a single humidistat to turn the fan on anytime humidity is greater than 60%, average humidity during the hours the fan operates should be well above 60% and the beans are likely to rewet to at least 13%. Since humidity is almost always higher at night than it is during the day, an alternative to a humidistat would be a timer set to just run the fan during nighttime hours.

If you aren't equipped to mix or remove beans after reconditioning, you need to avoid rewetting them to moisture levels that are too high for safe storage. One approach is to add a second humidistat that stops the fan when relative humidity reaches very high levels. Or you could also install a more sophisticated aeration controller that monitors both temperature and humidity and only runs the fan when air conditions

will bring the crop to the desired moisture content (for either drying or rewetting). The disadvantage of these approaches is that the fan doesn't run as many hours as it would with a single humidistat control and you would recondition fewer beans. Running the fan at high humidities and then mixing the wet and dry beans or removing the wet beans would result in reconditioning of more beans.

How long will it take to recondition a bin of beans?

Reconditioning time depends primarily on airflow per bushel and on humidity of the air moving through the beans. Reconditioning is fastest when airflow per bushel is high and humidity is high. Using a bin equipped with a full perforated floor, a good-sized fan that can deliver at least 0.75 cfm/bu, and a humidistat to prevent fan operation at low humidities will provide the quickest reconditioning. Even with this airflow, it would probably take at least a month of fan operation to move a rewetting front all the way through the bin. Using storage bins equipped with low-airflow aeration systems to recondition soybeans will require many months to move a rewetting front all the way through the bin.

Is there any danger of damaging the bin during reconditioning?

Soybeans swell when they absorb moisture, and experience during floods indicates that soaking the bottom few feet of beans in a bin can result in enough pressure to rupture bin walls. And a Michigan researcher reports that an attempt to recondition pea beans resulted in bin damage. We don't have enough information on reconditioning soybeans through use of aeration to know whether this procedure can damage bins, but the process will definitely increase stress on the walls. Using a vertical stirring auger to mix layers of dry and wet beans, or periodically removing wet layers of beans from a bin might be ways to reduce outward pressure generated during reconditioning.

Does reconditioning work best with upward airflow or downward airflow?

If it's possible to use downward airflow, that would be preferred for the following reasons:

- The reconditioned beans would be at the top of the bin where it would be easier to check moisture, to check for signs of mold, and to remove the reconditioned beans.
- Binwall stresses are likely to be lower if the rewet beans are at the top of the bin instead of beneath layers of dry beans.
- The heat generated by the fan motor and impeller are not working against you. Typical crop drying fans heat the air 2 to 3°F. This heat increases the drying potential of the air and is enough to lower the equilibrium moisture of the crop about 0.75 percentage points compared to the moisture you would get with air that is not heated by the fan. Contrary to popular belief, the heat generated by the fan is much greater than the amount of solar heat captured by the bin roof.

Most bins equipped for high airflow per bushel are designed for upward airflow and it is not easy to reverse the airflow direction. These upward-airflow systems can still be used for reconditioning, but recognize that you will have slightly greater stresses on the bin walls and you will need to probe to the bottom of the bin to monitor bean moisture changes. Also, if you are using a humidistat to control the fan, you might want to place the humidistat's sensing element between the fan and the bin so that it senses the air actually reaching the beans. Or if that's not convenient, increase the humidistat setting about five percentage points to compensate for the drying effect of the fan heat.

Caution: If you are able to reverse the airflow direction in a bin that was originally designed for upward airflow, make sure that roof vents are open anytime the fan is operating to avoid damaging the roof.

Summary

To increase chances of success in using aeration to recondition soybeans:

- Use timers, humidistats, programmable controllers, or some other type of automatic control to limit fan operation to weather conditions that will cause moisture increases. If the only control available is a single humidistat, set it to limit fan operation to weather conditions with relative humidity greater than 60%.
- If possible, use systems that pull air down through the beans to avoid the humidity reduction caused by fan heat, to limit stresses on bin walls, and to keep wet beans at the top of the bin where you can more easily monitor them and remove them from the bin.
- Either mix wet and dry beans by using stirring devices or by transferring beans from one bin to another, or periodically remove wet layers of beans from the bin. In systems that use downward airflow, remove wet layers of beans from the top of the bin. In systems that use upward airflow, consider using a tapered sweep auger to remove layers of wet beans from the bottom of the bin.
- Keep reconditioned beans cool to reduce chances of spoilage. Try to keep beans at 20 to 30°F during winter months and no warmer than about 50°F during other times of the year.
- Watch carefully for signs of moldy beans and for excessive stress on the bin.

The information in this article is based on ASAE Paper No. 99-6046, *Aeration Strategies for Reconditioning Dry Soybeans* by W. F. Wilcke, R. V. Morey, D. J. Hansen, and R. A. Meronuck.

Farmers and Elevators Must Segregate StarLink Corn

Bill Wilcke, Minnesota Extension Engineer

Farmers, elevators, and other grain handlers need to keep in mind that corn from genetically engineered StarLink hybrids has not been approved for human consumption and must not be mixed with corn that might end up in the human food supply. There were 29 StarLink hybrids available in 2000; they contain a gene from the *Bacillus thuringiensis* (Bt) bacteria and produce Cry9C protein that is toxic to some species of insects. The corn has been approved for livestock feed and industrial uses, but testing has not been completed to determine whether the Cry9C protein is a potential human allergen.

Farmers who grow StarLink hybrids and sell corn into commercial channels must clean combines, hauling vehicles, and grain conveyors when they switch from StarLink to other hybrids and they must store the StarLink corn in separate bins. When corn is sold, farmers need to tell buyers if the corn they are delivering is a StarLink hybrid and then the buyer must store the corn in separate bins and clean out conveying equipment after the corn has been handled.

Segregation is important, because human food products are being tested for evidence of the genes or Cry9C protein contained in StarLink hybrids and any products testing positive are being routed to other uses or recalled. Food recalls are very expensive for food companies both in terms of actual costs and in terms of negative publicity that is generated. It is likely that companies that need to recall food products will try to find the source of contamination and attempt to recover their costs from firms or individuals that caused the contamination.

Safety & Health

Safety Steps Can Pay Big Financial Dividends

John Shutske, Minnesota Farm Health & Safety Specialist

Avoiding farm work injuries that interfere with fall harvest can pay big financial dividends for crop producers. That is documented in a study by the University of Minnesota. The study indicates that lost time during fall harvest in the upper Midwest can cost a producer over \$300 per day. This total is separate from medical, hospital, and other related expenses.

We use a computer program that simulates a “typical” crop production season in which time is an important variable. Time is then “removed” to simulate downtime, or lost work time, due to unexpected events such as mechanical breakdowns and personal injuries. Financial information derived from our work suggests:

- Preparing machines before the harvest season will pay financially. This means performing routine maintenance, replacing worn parts, replacing safety shields, and making sure lights and flashers work and slow-moving vehicle emblems are clean. Machinery breakdowns during harvest are likely to result in frustration or anger that leads to excess stress as well as greater chance of injury.
- Safety is of utmost economic importance. Steps to increase safety include repairing safety equipment, making sure shields are in place, blocking up the combine header before working underneath, and making sure you are very visible when traveling on rural roads. Many serious lost-time injuries occur when getting in and out of a machine,

Eye Hazard from Hammering on Ball Bearings

Bill Wilcke, Minnesota Extension Engineer

An article in a recent issue of *Grain Journal* magazine included a note from a University of Minnesota ophthalmologist about injuries that can occur as a result of hammering on ball bearings. Dr. Eric R. Steuer said that he has treated a number of very serious eye injuries to farmers, farm workers, and a grain elevator mechanic who were injured when they tapped on ball bearings and small shards of brittle steel came flying off the bearings. Dr. Steuer would like “to alert readers that hammering on ball bearings is particularly dangerous to the eye” and he encourages use of eye protection when people are hammering or using power equipment.

Livestock Systems

Facility Design for the Transition Cow—Part 3

David Kammel, Wisconsin Extension Engineer
Kevin Janni, Minnesota Extension Engineer

This is the last of a three part series on transition cows. In the previous articles we discussed the design process and management plans. In this article, we discuss a variety of options and some design recommendations for housing transition cow groups to keep them clean, dry, and comfortable.

Design Features

A transition cow facility should be designed and built to implement the chosen management plan and provide a clean, dry environment with plenty of fresh air and feed and water for the animals. A well-designed facility should also be labor-efficient, economical, safe for both workers and cows, and environmentally friendly. This section provides design recommendations for facility elements or systems including freestalls, bedded packs and pens, walking surfaces, restraints, cow alleys, access to feed and water, ventilation, and lighting.

Freestall systems

Freestalls can be used to provide a clean and dry place for cows to lie down. They should be sized to prevent unnecessary forces on cows or injuries as cows get up and down. Freestalls should also be easily accessible from walk alleys. A freestall should be 45 to 48 in. wide and either 7 or 8 ft long depending on the stall divider and location in the building. The brisket board and neck rail should be 5½ feet from the rear curb.

Bedded pack system

A bedded pack can be used for both far-off and close-up cows. The bedded pack should be sized to provide 50 ft²/cow for far-off dry cows and 100 to 300 ft²/cow for close-up cows. The space needed for per cow depends largely on bed-

ding frequency and ability to keep the animals clean. This space does not include the feed bunk alley and scrape alley used for accessing feed and water. Bedding needs to be added regularly to provide a clean and dry place for cows to lie. The pen arrangement should allow easy bedding addition and manure pack removal with a skidsteer or front-end loader. Well-designed facilities are convenient to use and they limit labor requirements.

Pastures and open lots

Some farmers like to give transition cows a “vacation” from concrete or slatted floors by giving them access to dirt lots or pasture. Many farms would like to have cows calve on pasture when possible. Transition cow facilities can be designed to allow limited access to either pastures or open lots depending on the weather. A pasture is an area that is stocked at an animal density that maintains vegetative growth throughout the growing season. Excessive use of a pasture can result in a muddy lot, which is not recommended. A dirt lot usually does not have vegetative growth and cow access should be limited depending on the weather. A dirt lot should not be used when it is muddy. Cattle mounds may be incorporated into outside lots to improve drainage. Muddy conditions can also be limited by using geotextile fabrics in a designed all-weather surface. More information is available in MidWest Plan Service AED-45, *Using All-Weather Geotextile Pads and Lanes* (copies can be purchased from either the University of Wisconsin Biological Systems Engineering Department or the University of Minnesota Biosystems and Agricultural Engineering Department). Lot runoff needs to be handled according to local and state regulations to prevent pollution.

Maternity or treatment pens

Individual pens should be approximately 12 ft x 12 ft or 10 ft x 14 ft (approximately 140 ft²/cow). They can have a concrete, clay, or sand base with at least six inches of organic bedding placed on top. Although concrete floors are more easily cleaned, they might not provide the best footing surface for cows. Clay, soil, or sand bases allow better footing for cows and allow relatively easy cleaning of pens with skidsteer loaders. Sanitation is an important design consideration in maternity and treatment pens. In maternity pens especially, manure must be removed frequently to prevent the transmission of diseases such as Johnes to newborn calves through contact with the cow’s manure. Treatment pens should also be cleaned before use by another animal to prevent disease transmission.

Restraint for treatment

Tie stalls or stanchions can be used to provide cow restraint, but they are not necessarily the best choice for housing cows. There is a significant amount of hand labor involved in feeding cows and removing manure from these stalls. The number of cows housed in this way should be kept to a minimum.

Headlocks are a popular restraint option for group freestall or bedded pen arrangements. The headlocks are placed at the feed bunk and are used consistently by the animals. Animals can be caught and restrained at any time. Individual pens

with a gate positioned to swing towards a head gate can be used to catch and restrain a cow.

Each group should also have appropriate and convenient access to health care and treatment facilities. A squeeze chute, hoof trimming table, or surgery table are nice features for any size herd, but they are becoming very popular for larger herds that have regular herd health checks by a veterinarian. These facilities should be easily accessible to a veterinarian's truck and to the farm's vet supply area or office.

Alleys

Freestall and bedded pack group pens should have feed bunk alleys and scrape alleys to allow cows to access feed and water. Scrape alleys should be laid out for easy manure removal. Gates at appropriate locations allow for easily moving cows from one group to another or for sorting individuals from a group. The alley and gate layout should allow one person to sort and move an individual or group of cows safely. Concrete alley surfaces should be made non-skid to prevent cows from slipping. Alleys should be grooved when the concrete is placed, or grooves can be sawn in when the concrete is green. Grooves can also be cut into old concrete alleys.

Personnel safety passes

Personnel safety passes are 12- to 14-in. clear openings placed in pen partitions to allow easy access and escape from any pen. Personnel passes should be placed in all group pens and individual pens. Also, pen partitions and gates should be hung at a height that allows people to roll under the gate or fence to escape the pen in an emergency.

Waterers

At least one waterer should be available to each group or individual pen. Waterers placed at opposite ends of a freestall row or bedded group area allow access even if a "boss" cow is dominating one waterer. Waterers should have shallow water depth (6 to 8 in.), be mounted at the correct height (32 in.), and allow easy cleaning and draining.

Feed manger

The separate transition cow groups are usually fed different rations. Flat feeding floors with post and rail-feeding fences allow easy cow access to feed. Flat floors also allow easy feed delivery, pushing up of feed, and cleaning by workers. Headlocks are a common option as a feed barrier.

Lighting

Lighting is important for cow observation and care, especially in maternity and treatment pens. Metal-halide and high-pressure sodium lamps are popular, energy-efficient options for cold areas where lamps can be mounted at least 11 ft high. Fluorescent lamps are also energy efficient and they can be used in warm areas along with incandescent lamps. Fluorescent lamps are usually mounted 7- to 8-ft high. Special high light output (HLO) fluorescent lamps can be mounted 8- to 12-ft high. Fluorescent lamps with electronic ballasts can start at colder temperatures (down to 0°F). Lamps with electromagnetic ballasts need warmer temperatures (40°F or higher). Spot lamps or flood lamps may be needed in treat-

ment areas used for surgery. Colors are truer when observed under lamps with higher color rendition index (CRI) values. Incandescent, halogen, fluorescent, and metal-halide lamps have higher CRI values than high-pressure sodium and mercury-vapor lamps. Mercury-vapor lamps are not recommended for cow areas.

Ventilation

Ventilation is necessary for providing fresh air and for removing moisture and animal heat. The majority of newly designed dairy facilities use natural ventilation where wind and thermal buoyancy (warm air rises) provide the driving force for air exchange. Air enters through side wall and eave inlets and exits through the open ridge and downwind sidewalls. Insufficient inlet and outlet openings lead to condensation on building surfaces in cold weather and heat build up in hot weather. Naturally ventilated barns are designed to provide shade in the summer and draft control with curtain sidewalls in the winter. Supplemental cooling fans may be used in the summer on hot, still days.

In some designs, supplemental heat is needed to improve working conditions for the veterinarian or herd manager in a hospital area. Radiant heaters, which heat surfaces, work well in open areas while unit heaters are generally used for heating mechanically ventilated spaces. Mechanical ventilation is generally used only for small hospital areas or for retrofitting existing mechanically ventilated stall barns. Mechanically ventilated spaces need sufficient fan capacity, well-distributed and properly sized inlets, and controls.

Manure handling

Animal manure will be generated wherever cows are housed (i.e., free stall group pens, manure pack pens, and maternity pens). Different housing and bedding choices will require an appropriate manure handling system and equipment. Consider manure form, bedding use and storage, manure collection and storage, and the equipment needed. These options can be considered during the design process to develop an overall manure management plan.

Choose the System Design

There is no single "best" design. Every design involves trade-offs. The difficult task is to incorporate as many of the design criteria desired into a functional, practical, and buildable plan. Some design principles might have to be compromised slightly to be part of the overall design. If the design principles have been prioritized, the job of deciding which features to keep or eliminate can be made more easily because the decision process is already in place. Well-designed transition facilities fit the management plan, provide cow comfort and care, are convenient and safe for workers, and are economical.

Assess the trade-offs of each design option. Try to determine which combination of design choices provides the most balanced design. The solution should meet all of the required criteria set forth in the management plan and building specifications, and most of the highest ranked desired features. The

selected design should be somewhat “better” than other alternatives.

Implement the Design

Finally, draw a scaled plan for bidding or building purposes. The plan helps define the space and conveys the specifications of what is to be built to the builder and to others involved. The specifications of the building will describe the facility in terms that a builder or contractor can understand. A complete plan will help the builder and other contractors to build the facility the way you planned it.

The scaled plan can be used to evaluate the overall design and its impact on all aspects of the management plan. The dairy design team can review and critique the design. The herd manager and other employees can consider how they will perform their assigned tasks. The scaled plan can be used to evaluate cow, feed, manure, and employee routines.

Retrofitting Existing Facilities

In some cases, existing facilities can be used to house and manage a transition cow group defined in the management plan. Evaluate the existing facility to determine its function in the plan. If the space can meet the needs described in a reasonable fashion with cost-effective modifications, then it might be a viable alternative. If the retrofit does not meet the functional design, then it might not be a good decision even if it is a very low cost modification.

Summary

Facility design is a fluid process involving give and take. It is easy to lose sight of the original intent along the way. Design the facility to implement the transition cow management plan and consider each of the design features to develop a comprehensive facility design.

New Publications

New Publications Available from MWPS

Bill Wilcke, Minnesota Extension Engineer

Conservation Tillage Systems and Management, MWPS-45, Second Edition is a revised and expanded version of an older MidWest Plan Service (MWPS) conservation tillage book. The new 270-page book contains color illustrations and 29 chapters. Topics include descriptions of different tillage systems and equipment; erosion and water quality; residue management; crop, nutrient, and pest management; and economics. Chapter authors include consultants, industry personnel, and engineers and scientists from government agencies and from universities all over the U.S. The book is an excellent reference for farmers and for people who advise them. The cost of the book is \$25 plus sales tax.

Greenhouses for Homeowners and Gardeners, NRAES-137, is a new 214-page book that covers every aspect of designing

and constructing a home greenhouse. Eight chapters discuss the following topics: greenhouse basics, selecting a greenhouse, greenhouse planning, framing materials and glazing, greenhouse layouts and equipment, the greenhouse environment, window greenhouses and growth chambers, and garden structures.

The book will help readers select and design the most appropriate size and style of greenhouse to fit their needs, find the best place to locate a greenhouse, and decide whether to build a greenhouse themselves or hire a contractor to do it. It will enable aspiring and practicing greenhouse operators to make informed decisions about foundations, glazing and framing materials, space utilization, interior design, heating and cooling systems, supplemental lighting, watering and fertilizing systems, and other greenhouse design and construction issues.

Ten diverse do-it-yourself plans for home greenhouses and other garden structures are provided in an appendix. Each plan includes materials lists and construction diagrams and details. Three additional appendices contain a greenhouse maintenance checklist, lists of greenhouse and equipment suppliers, and useful conversions. The book also features nearly 150 line drawings; 20 tables; equations for determining heating, cooling, and lighting needs; a glossary; and an index. *Greenhouses for Homeowners and Gardeners* addresses a wide audience, including gardeners, homeowners, cooperative extension educators, and institutions (such as retirement homes, schools, and prison associations). Small farmers may also find the book useful. The cost of the book is \$25 plus sales tax.

These books and many other MWPS publications can be ordered from either the University of Minnesota or the University of Wisconsin.

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Calendar of Events

November 14-16, 2000, **4th Decennial National Irrigation Symposium**, Phoenix, AZ. Contact Brenda West (800) 371-2723 or west@asae.org

November 29, 30 & December 1, 2000, **Minnesota Dairy Extravaganza-2000** (in conjunction with the North American Farm & Power Show), Minneapolis Convention Center, Minneapolis, MN. Contact Ed Frederick (507) 835-3422.

December 5-8, 2000, **National Conference on Grazing Lands**, Bally's Las Vegas, Nevada. See website at www.glci.org

December 14, 2000, **Central Minnesota Dairy Expo**, Holiday Inn, St. Cloud, MN. Contact Jim Salfer (320) 255-6169.

January 9-10, 2001, **Wisconsin Frame Builders Conference and Tour**, Madison, WI. Contact David Kammel (608) 262-9776 or dwkammel@facstaff.wisc.edu.

January 9-10, 2001, **Minnesota Forage Conference**, Holiday Inn, Detroit Lakes, MN. Contact Betty Schiefelbein (651) 436-3930.

February 8-9, 2001, **Minnesota Organic Conference**, St. Cloud Civic Center, St. Cloud, MN. Contact Doug and Janet Gunnink dgunnink@prairie.lakes.com or (507) 237-5162.

March 15-17, 2001, **Upper Midwest Organic Farming Conference**, Campus of University of Wisconsin, La Crosse, WI. Contact Faye Jones fjeoc@win.bright.net or (715) 772-3153.

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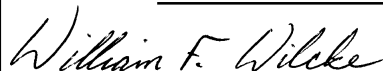
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University of Minnesota, United States Department of Agriculture, and Minnesota Counties Cooperating

University of Minnesota Newsletter Team: Bill Wilcke and Deb Hansen. This publication is available in alternative formats upon request.



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