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EC98-792 Farm*A*Syst Nebraska's System for Assessing Water Contamination Fact Sheet 16: Improving Crop Pesticide Application Management

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FACT SHEET 16

Nebraska's Farm Assessment System for Assessing the Risk of Water Contamination

Improving Crop Pesticide Application Management

Though pesticides are especially harmful to the target pest, they are also potentially harmful to most living and breathing creatures and non-target plant life. Proper handling and application management of pesticides are important to protect you and to protect surface and groundwater from contamination. Pesticides were first found in groundwater in the 1970s. Prior to that, the general belief was that pesticides did not leach into the groundwater with normal use.

1. Management Skills

The goal of pesticide application management is to prevent contamination of surface water and groundwater from pesticides. The basic concept of pesticide management is to safely use pesticides without causing degradation of the environment. The most effective approach to reducing pesticide pollution is to release less pesticide or less toxic pesticides into the environment and to use practices that minimize the movement of pesticides to surface water and groundwater.

Integrated Pest Management (IPM) is a systems approach to managing crop pests that focuses on strategies to prevent economic pest damage. A balance of pest control methologies is used in order to blend into a single system a variety of methods and tactics. Rather than seeking to eradicate all pests entirely, IPM strives to prevent their development or to suppress pest population numbers below levels that would be economically damaging. By using IPM, high quality food and fiber production is maintained and pest populations are most economically controlled while safeguarding human health and environment.

Integrated pest management can help minimize the amount of pesticides applied. IPM emphasizes biological control and the conservation of natural enemies already occurring in the environment. It offers a more efficient and sensible approach to pesticides, thus increasing their effectiveness and useful life span and decreasing possible adverse affects.

The following steps generally are part of an IPM plan:

1. Identify the pest.
2. Determine levels of pest infestation and evaluate the damage the pest has caused.
3. Determine if controls are needed. In crops, compare the cost of the pest control to potential costs or losses caused by the pest if no controls are used. It may cost less money to control the pest than to allow the pest to continue its damage. Use pest controls only when that method(s) will prevent the pest from causing more damage than is reasonable to accept.

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Elbert C. Dickey, Interim Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.

4. Identify previous pest control measures, cropping history and soil types.
5. Evaluate available control methods. Six choices are:
   a. Host resistance (the crop resists the pest or the damage the pest causes)
   b. Biological controls (control of pests by other living organisms or natural enemies such as bacteria or preying insects)
   c. Cultural controls (crop rotation, cultivation, tillage, date of planting, mulches, fertilization, etc.)
   d. Mechanical controls (screens, traps, physical removal of individual weed plants or insects)
   e. Sanitation (cleaning of equipment, weed-free crop seed, removal of food supplies and shelter that attract pests)
   f. Chemicals (pesticides)
6. Select the combination of pest control methods that is most effective to protect people and their environment. Monitor your decision.
7. Evaluate sites where pesticides or pest control agents will be stored, mixed, and loaded.

The Environmental Protection Agency recommends these IPM strategies to help reduce or eliminate the use of pesticides:

- Biological Controls: Introduction and fostering of natural enemies, preservation of predator habitats, and release of sterilized male insects
- Pheromones: Monitoring populations, for mass trapping, for disrupting mating or other behaviors of pests and to attract predators and parasites
- Rotating crops to reduce pest problems
- Improvement of tillage and planting practices, such as ridge plant
- Use of cover crops in the system to reduce erosion and deep percolation of water that contributes to leaching of pesticides into groundwater
- Destruction of pest habitats
- Use of mechanical destruction of weed seed
- Habitat diversification
- Pesticide application based on sound economic thresholds
- Resistant crop cultivar selection
- Regular scouting to determine when pest problems reach the economic threshold
- Proper timing of IPM action
- Efficient application methods such as spot-spraying and banding when appropriate
- Cleaning equipment to eliminate transfer of pest from field to field or infestation of storage

2. Field Operation Procedures Using IPM

Crop scouting

Regular field scouting or monitoring of the field is recommended to check levels of pest populations and their potential damage. Cost-effective pest management is dependent on a strong scouting program. Scouting should tell you: 1) what kinds of pests are present; 2) if the numbers present are great enough to warrant control; 3) when to begin control measures; and 4) if the control efforts successfully reduced the number of pests.

Scouting techniques include such things as recording temperature and other weather conditions, regular surveys for pests or their damage, use of insect traps, and observing pest and crop growth stages. Scouting is necessary to help determine the best possible plan of action, be it a pesticide application or other management actions. Scouting can be accomplished by a trained family member or a hired crop consultant. Educational materials and training are available through the Field Crops IPM Program at the University of Nebraska, Cooperative Extension. Obtain information from the University of Nebraska Cooperative Extension when pests may become a problem.

Crop rotation

Non-chemical control measures for insects and weeds such as mechanical, cultural and biological controls, sanitation, and plant resistance are highly recommended, For example, rotating corn with soybeans can manage corn

rootworms, cutting alfalfa early can manage weevils, etc.

Crop rotation can allow land used for crops with high pesticide needs or highly erosive crops to be planted periodically with crops that are less pesticide-intensive or crops that conserve soil better. This will reduce the concentration of any single pesticide in runoff or soil and reduce the chance for groundwater contamination. Crop rotation also improves the control of problem and escape weeds. This practice eliminates the repeated use of the same pesticide in a specific field, which can result in the development of resistance of the pest to a pesticide.

Avoid using fields that might encourage pests or pose other environmental problems whenever possible. Keep and use records of soils information, pest history and pesticide use.

Tillage practices

Water quality is affected by tillage practices. Reduced tillage generally results in less water runoff. During a rainfall event, rain mixes with the soil in a thin mixing zone at the soil surface (usually the top half-inch) and either runs off or infiltrates. Runoff begins when the rainfall rate exceeds the infiltration rate. Chemicals located on the surface or in the mixing zone will suffer significantly greater losses in surface water runoff than in areas which were not treated or where chemicals were incorporated with tillage.

No-till practices leave the soil undisturbed from harvest to planting except for nutrient injection. They can reduce surface water runoff and increase infiltration for well-drained soils. Macropores (earthworm burrows, large root tunnels, and/or large expansion/contraction cracks) are far more prevalent because of the lack of disruptive tillage. No-till might not reduce runoff from poorly drained soils, or soils with a shallow impermeable layer.

Ridge plant requires less herbicide than other tillage methods when band application and cultivation are used. The soil is left undisturbed from harvest to planting except for nutrient injection. Residue is left on the surface between ridges, and ridges are rebuilt during cultivation.

A mulch-till program uses minimum tillage prior to planting and requires herbicides or cultivation for weed control. Tillage that buries residue generally reduces water infiltration and increases water runoff.

Conservation tillage practices help control wind and water erosion and reduce the number of machinery passes over the field, but the crop residue may harbor some diseases and insects and encourage their presence. Use crop rotations to manage crop residue for maximum soil conservation and to minimize pest populations.

Crop management

Manage crops to compete with weeds. Good management practices may produce a vigorous crop that will compete with weeds for space, light, moisture and nutrients. The timely use of mechanical weed control can reduce and even eliminate the need for herbicides. Practices range from seedbed preparation to hand hoeing. Cover crops may also reduce weed infestations.

Plant a “trap” crop. Sometimes insects are more intensely attracted to one crop than another, but if the usual host is not available, alternate hosts may be found. Planting a host or trap crop to divert target insects, planting a border, or planting a small plot of the main crop earlier than the remainder are examples of trap crops.

Strip cropping is the process of alternating crops such as corn and alfalfa in relatively narrow strips along the contour of the field. The runoff from the corn is captured in the downhill alfalfa strip, thereby retaining sediment and water in the field, reducing pesticides in runoff from leaving the field. Strip width will be dependent upon field slope and slope length. Strip cropping is also used to reduce wind erosion if the strips are perpendicular to the prevailing wind direction.

Contour buffer strips slow the movement of water flowing on the soil surface. This

allows more time for water to infiltrate, thus reducing runoff from the field. Although pesticide will be contained in the sediment and/or the runoff water, it can be partially contained in the buffer strips rather than moving off the field where it could threaten surface water elsewhere.

Application timing

Consider environmental risks when applying pesticides. Off-target drift caused by wind or other factors should be avoided. The type of soil, pest population, and instructions on the label can help you determine the proper time for application and the amount of chemical needed. Vapor pressure of the pesticide, wind speed, temperature, vertical air movement, humidity, and equipment operation (especially pressure) affect the spray droplet size, particle and vapor drift, and application success.

Consider soil moisture condition prior to pesticide application. Some pesticides require moisture for activation. If the soil is dry, some water in the form of rainfall or irrigation following application will be needed to activate the pesticide. On the other hand, if the soil is at or very near saturation, any additional moisture has the potential to leave the field as surface runoff or to be lost through the profile in the form of deep percolation.

Pesticides that reach the soil surface are said to be in the "mixing zone," i.e. the top one-half inch of soil where they may adsorb to soil or dissolve in water from irrigation or rainfall. Rainfall can either infiltrate into the soil or run off. Dissolved pesticides will move with water. Soil erosion removes pesticides attached to soil particles. For example, typical annual runoff losses of atrazine are 1-5 percent of the total amount applied. Of this, 80-90 percent is lost in runoff water, with the remainder attached to the eroded soil. The majority of the atrazine losses occur during the first heavy rains after application.

Sometimes even though a pesticide has been applied, the pest has not been controlled. Review the situation to determine what went wrong. Pests do become resistant to pesticides. Each time a pesticide is used, it selectively kills the most susceptible pests. Some pests usually survive by avoiding the pesticide or withstanding its effects. Pests not destroyed may pass along the trait that allowed them to survive which can eventually lead to pesticide resistance.

Using one pesticide repeatedly in the same place against the same pest can cause the surviving pest population to build up more resistance to the pesticide than the original population. A pesticide that leaves a residual with lowered effectiveness will help select out resistance. Rotating pesticides with different modes of action may help reduce the development of pest resistance, e.g. rotating from an organophosate to a pyrethrin chemical family.

Sometimes a pesticide application fails to control a pest because the pesticide was not applied at an appropriate time. The pest may not have been in the area during the application or it may have been in a life cycle stage or location where it was not susceptible to the pesticide.

3. Characteristics

Knowing the soil type where you are applying pesticides will help in understanding the potential for surface water or groundwater contamination. *Worksheet 2, Site Evaluation*, takes you step-by-step through soil texture, depth to groundwater, and surface water contamination potential. If your soils rank high in contamination potential, your success in using pesticides safely depends on understanding pesticide characteristics. If your soils rank low in contamination potential, knowledge of the use of pesticides can help prevent the potential of pesticide buildup and contamination of water by good management practices.

Pesticide movement away from the target pest in the field is influenced by factors besides wind and vapor drift (see Figure 1). They include:

- **Adsorption:** Pesticides, through a chemical process, can be bound or adsorbed to the surface of a soil particle.

For example, portions of a pesticide molecule may bind to clay materials or organic matter in the soil. Pesticides with high water solubility, low tendency to adsorb to soil particles and long persistence or half-life have the highest potential to move into water. Pesticide movement is not dependent on adsorption, solubility, or half-life only, but on the interaction of all these factors along with the soil texture and environmental conditions at the site. Pesticide molecules tend to bind to fine-textured soils (silty clay) more readily than to coarse-textured soils (sandy loam).

- **Degradation:** Pesticides will break down after application by either microbial action, chemical action or photodegradation. The process may take hours, days, weeks or years, depending on environmental conditions and the chemical characteristics of the pesticide.

Factors influencing whether pesticides will leach into groundwater include characteristics of the soil and pesticide and their interaction with water from irrigation or rainfall.

- **Transfer:** A pesticide can be moved away from the application site by runoff, volatilization, leaching, absorption and crop removal. Pesticide transfer is sometimes essential for pest control. For example, some pre-emergence herbicides must move within the soil to be absorbed by germinating weed seeds, shoots, or roots.

Runoff occurs when water is added by rainfall, flooding or irrigation faster than it can infiltrate into the soil. Pesticides may move with runoff as compounds dissolve in the water or attach to soil particles (adsorption). The greatest loss generally occurs during the first heavy runoff event after application.

Volatilization occurs when a liquid or solid converts to a gas and moves away from the initial application site.

Leaching is the downward movement of chemical through the soil, potentially reaching groundwater.

Absorption is the uptake of pesticides or other chemicals into the plant or animal. After absorption, the pesticide residue may be broken down or be removed off site at harvest or by grazing.

For a list of commonly used pesticides in Nebraska, refer to **Understanding Pesticides and Water Quality in Nebraska,** EC 94-135. Pesticides are identified by their characteristics, maximum containment levels, water solubility, half-life, and other traits that can help you determine which pesticide is right for your soil and other factors in your crop management practices.

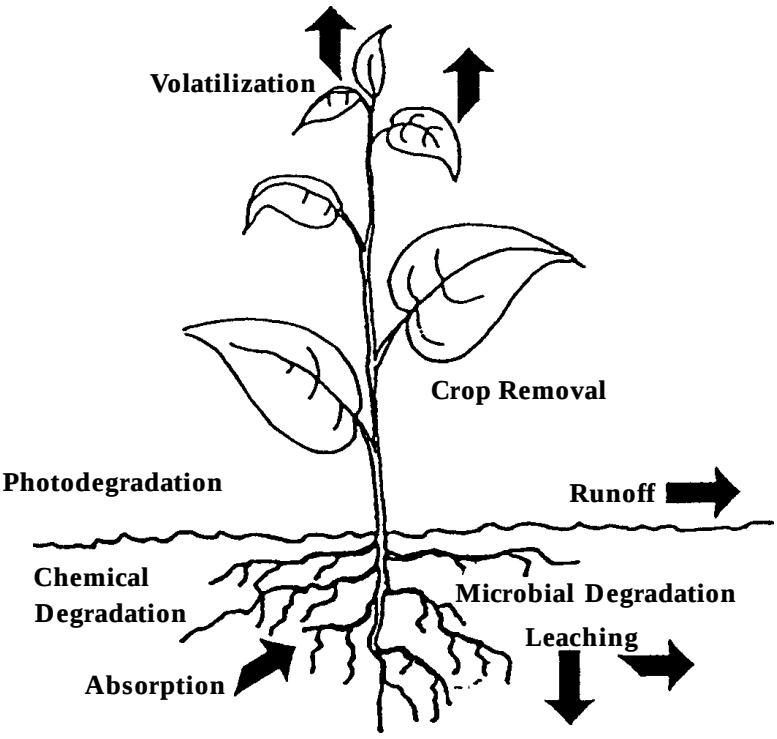

Figure 1. The fat processes of pesticides.

Understanding what happens to pesticides while and after they are applied in the field is important. Depending upon the size of the pesticide spray droplet, wind can be a factor in the movement of pesticides to unwanted areas. The effect of droplet size on drift potential is listed in *Table 1*. The longer a pesticide droplet is suspended in the air, the greater the potential for drift to occur. Review the drift control measures in the "minimizing spray drift" section of this publication.

Table 1. Influence of droplet size on product movement through still air.

Diameter in microns	*Time for droplet to fall 10 feet in still air*
1 (fog)	28 hours
10 (fog)	17 minutes
100 (mist)	11 seconds
200 (fine spray)	4 seconds
400 (coarse spray)	2 seconds
1,000 (coarse spray)	1 second

4. Education and Training

Applying the right amount of pesticides at the right time to achieve desired results requires learning about the product you use. Read all label instructions thoroughly. The labeling may tell you to consult another source for details about your situation. Your legal responsibility for following separately distributed instructions are the same as for instructions appearing in full on the pesticide label.

The Material Safety Data Sheet (MSDS) offers additional helpful information. The MSDS identifies the ingredients, chemical makeup, health data, first aid procedures, protective handling measures, environmental waste-container disposal methods, and shipping requirements. You are responsible to be educated in the proper use of the pesticide. Family members and others around the farmstead should also be familiar with the safety and health information contained in the MSDS.

Pesticide training and certification

Restricted use pesticides require certification by the Nebraska Department of Agriculture prior to use or application. Applicators can qualify for certification either by attending Cooperative Extension training or by completing self-study training materials. Commercial and non-commercial applicators must complete both a general standards exam and at least one specific category exam. Training for commercial and non-commercial pesticide applicators is also provided by the University of Nebraska Cooperative Extension.

Users of registered pesticides on the farm should have an Emergency Response Plan, or adhere to established Best Management Practices (BMP). The plan lists steps to take in an emergency, a directory of authorities to contact, and a current list of all pesticides in use or in storage. The plan should be filed and rehearsed to familiarize potential participants with the procedures.

Record-keeping

Private applicators must record their usage of a restricted use pesticide (RUP) as required by the Food, Agriculture, Conservation and Trade (FACT) Act of 1990. The USDA Agricultural Marketing Service is the regulatory authority for this legislation. The Nebraska Pesticide Act has adapted these same record-keeping requirements for private applicators in Nebraska but extended the length of time to keep the records to three years. A private applicator may elect to keep (RUP) records in any fashion: handwritten, on invoices, computerized, in record books, etc. The required components for each application of a restricted use pesticide include:

- Brand / product name of pesticide
- EPA registration number
- Total amount of RUP applied
- Crop or site treated
- Field location
- Acres treated
- Application date
- Name of the certified applicator
- Certification number of the applicator

Keeping records on all pesticides used may help reduce the amount of pesticides

needed. For example, keeping records of *all* pesticides used for each field, date of application, the number of acres, crops grown, crop production, soil types, and past pest problems can reveal trends useful in improving management practices. Records can also help establish Integrated Pest Management (IPM) strategies to reduce long-term reliance upon pesticides.

5. Application Practices and Equipment Maintenance

Sprayer calibration

A Nebraska survey found only one of three sprayer operators were applying pesticides within five percent of their estimated rate. The survey results clearly indicate that sprayers must be checked to ensure all nozzles are applying pesticides uniformly and at the correct rate. Make sure your equipment is working properly and calibrated to ensure the correct amount of pesticide is delivered to the target area. Pesticide applications greater than the label rate results in needless risk to groundwater, increased production costs, crop damage, is illegal and could result in the rejection of the sale of the crop. Underapplication might be costly by not properly controlling the target pest. Although you can sometimes repeat the application, doing so is time-consuming, costs more, and increases the risk of applying too much. The label will list the maximum rate you can apply at any one application or season. Replace older equipment with newer, more precise application equipment as the opportunity arises.

Regular sprayer calibration includes measuring the output of each nozzle to ensure all nozzles are functioning properly. Specific calibration guides are available from a number of sources. Sprayer calibration should be done every time a different pesticide and / or carrier is applied.

Calibrate means to test equipment performance. The rate of application depends partly on the particle or droplet size, texture, carrier density, and other properties of the pesticide being applied. Use only water during the test if the pesticide is a liquid. Corrections may be needed if the carrier is different from water. For example, using UAN 28% as a carrier for a pesticide will reduce the nozzle flow rate by about 13%. Contact the manufacturer to get reliable information regarding carrier material to perform the tests if the pesticide is a dust, granule, or fumigant, or a liquid diluted with a liquid other than water.

Follow calibration and mixing instructions carefully. Mixing, loading, and calibration methods must also conform to the speed of the application machinery. Moving too fast or too slow changes the rate of application.

Minimizing spray drift

Spray drift, movement of a pesticide through air during or after application to a site other than the intended site of application is considered to be a challenging issue facing pesticide applicators. Complete elimination of spray drift is impossible. However, drift can be minimized by following these drift control measures:

1. Select low or nonvolatile pesticides.
2. Read and follow the pesticide label.
3. Use spray additives following label guidelines.
4. Use large orifice sizes for spray nozzles.
5. Avoid high sprayer pressures which create finer droplets.
6. Use drift reduction nozzles.
7. Use wide angle nozzles, lower spray boom heights, and keep spray boom stable.
8. Do not spray when wind speeds exceed 10 mph and when wind direction is directed toward sensitive vegetation.
9. Use a shielded spray boom when wind conditions exceed ideal conditions.
10. Avoid spraying on extremely hot and dry days, especially if sensitive vegetation is nearby.
11. Keep good records and evaluate the results.

Personal protective equipment (PPE)

The pesticide labeling may require wearing specific items during some activities. You are legally required to follow all personal protective equipment instructions on the label. Be aware that the required PPE may differ if one is mixing / loading a pesticide versus applying the product. Use common sense, information on the label about precautions to humans, and your knowledge of the task you will perform to help assess potential hazards and to select appropriate personal protective equipment for each job.

Selecting protective clothing material for a given pesticide is important. How resistant a material is needed will depend on the length of exposure, the exposure situation, and the chemical to which the material is exposed. The Environmental Protection Agency, Department of Agriculture, and University of Nebraska Cooperative Extension, among others, can offer suggestions about which materials are resistant to particular pesticides.

6. Distance and Separation of Pesticide Application from Water Sources

When loading, unloading, storing, transporting, or applying pesticides, remain at least 50 feet and preferably 100 feet away from a well. Leave a buffer zone around sensitive areas. Read the pesticide label for guidance on required buffer zones around water, buildings, wells, wetlands, wildlife habitats and other sensitive areas where applications are prohibited. As an example, consider the following statement taken from an Atrazine label.

> *"Atrazine may not be mixed/ loaded or used within 50 feet of any well, including abandoned wells, drainage wells and sink holes, or within 50 feet of intermittent streams and rivers, natural or impounded lakes and reservoirs. It may not be applied within 66 feet of the points where field surface water runoff enters perennial or intermittent streams and rivers or within 200 feet around natural or impounded lakes and reservoirs."*

Chemigation is a method of pesticide and / or fertilizer application via the irrigation water. Refer to *Worksheet 15, Irrigation Wellhead Protection*, for more information on reducing the risk of groundwater contamination from pesticides reaching the water source through the wellhead.

Point source contamination, such as spills, happen most often when the pesticide is mishandled or improperly applied. See *Fact Sheet 4, Improving Pesticide Storage and Handling,* for information concerning storage, handling, and what to do if a spill occurs.

CONTACTS AND REFERENCES

Who to call about...

Laws and Regulations concerning Restricted Use Pesticides

The Nebraska Department of Agriculture, Plant Industry, P.O. Box 94756, Lincoln, NE 68509-4756; (402) 471-2394

The Nebraska Department of Environmental Quality, P.O. Box 98922, Lincoln, NE 68509; (402) 471-2186.

The U.S. Environmental Protection Agency (EPA), Office of Pesticide Programs (TS-766C), 401 M Street S.W., Washington, D.C. 20460.

What to read about...

- Publications are available from sources listed at the end of the reference section. (Refer to number in parentheses after each publication.)
- *Management Measures for Agricultural Sources*. Environmental Protection Agency (EPA-840-B-92-002), Chapter 2. (2)
- *On-Farm Agrichemical Storage and Handling*. June 1992. Michigan State University Extension Bulletin E-2335. (5)
- *Understanding Pesticides and Water Quality in Nebraska*. Extension Circular EC 94-135. (1)

- *Best Management Practices for Agricultural Pesticides to Protect Water Resources*. NebGuide G93-1182. (1) (7)
- *Agricultural Resources, Cropland, Water, and Conservation, Situation and Outlook Report*, United States Department of Agriculture, Economic Research Service AR-30. (4)
- *Best Management Practices for Wheat, A Guide to Profitable and Environmentally Sound Production*. The National Association of Wheat Growers Foundation, Cooperative Extension System. (6)
- *Pesticide Laws and Regulations.* NebGuide G479. (1) (7)
- *Worker Protection Standards for Agricultural Pesticides.* NebGuide G1219. (1) (7)
- *Rinsing Pesticide Containers.* NebGuide G1150. (1) (7)
- *Protective Clothing and Equipment for Pesticide Applicators.* NebGuide G758. (1) (7)
- *Signs and Symptoms of Pesticide Poisoning.* Extension Circular EC 2505. (1) (7)
- *Federally Registered Restricted Use Pesticides.* Extension Circular EC 2500. (1) (7)
- *Field Records for Restricted Use Pesticide Applications and Integrated Crop Management by Private Applicators.* Extension Circular EC 2540. (1) (7)
- *Laundering Pesticide Contaminated Clothing.* NebGuide G943. (1) (7)
- *The Pesticide Label.* NebGuide G937. (1) (7)
- *Spray Drift of Pesticides.* NebGuide G90-1001. (1) (7)
- *Fertilizer and Pesticide Containment Guidelines.* NebGuide G94-1185. (1) (7)
- *Plumbing Systems of Agricultural Sprayers.* NebGuide G91-1020. (1)
- *Fine Tuning a Sprayer with the "Ounce" Calibration Method.* NebGuide G88-865. (1) (7)
- *Nozzles — Selection and Sizing.* NebGuide G89-955. (1)
- *Set Up of Tillage, Planting and Directed Spray Equipment.* NebGuide G91-1019. (1)
- *Design and Management of Storage Containment of Fertilizer and Pesticides.* Extension Circular EC95-744. (1)

Publications available from...

1. Your local University of Nebraska Cooperative Extension office or directly from IANR Communications and Computing Services, 105 Ag Communications Building, P.O. Box 830918, University of Nebraska-Lincoln, Lincoln, Nebraska 68583-0918, (402) 472-7912. There may be charges for the publications, postage and sales tax. Or check the University of Nebraska Cooperative Extension Catalog of Publications Internet site, http://www.ianr.unl.edu/pubs/
2. U.S. Environmental Protection Agency (EPA), Office of Pesticide Programs (TS-766C), 401 M Street S.W., Washington, D.C. 20460.
3. Midwest Plan Service publications are available through your local extension office or Agricultural Engineering Plan Service, 219A L.W. Chase Hall, University of Nebraska-Lincoln, Lincoln, Nebraska 68583-0727, (402) 472-1646.
4. U.S. Department of Agriculture, Economic Research Service, 1301 New York Avenue NW, Washington, D.C. 20005-4788.
5. Michigan State University Extension, E. Lansing, MI, 48824. There may be charges for the publications, postage and sales tax.
6. National Association of Wheat Growers, 415 Second Street, NE, Suite 300, Washington, DC, 20002, (202) 547-7800.
7. Pesticide Education Resources Internet site, University of Nebraska-Lincoln. http://www.ianr.unl.edu/ianr/pat/ephome.html

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