Best Management Practices for Irrigation

BEST MANAGEMENT PRACTICES

FOR POLLUTION CONTROL

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Abatement of Nonpoint-source Pollution from Agricultural Irrigation

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Introduction

We **ALL** need Clean Water. It is essential to life—to our social, cultural, and economic well being. Clean water is especially important to agricultural producers who use it for watering livestock, cleaning equipment, processing, and irrigating their crops. Increased concern for the deteriorating quality of our nation's waters led to the passage of the Federal Water Pollution Control Act Amendments of 1972 and the Clean Water Act of 1977. These laws require each state to plan for the control or abatement of nonpoint-source pollution.

Nonpoint-source pollution results from runoff, snow melt, or groundwater seepage from industrial, municipal, and agricultural sites. Nonpoint-source pollution often goes unnoticed; however, it is extremely widespread and makes a significant contribution to our overall water pollution problem.

All forms of agricultural production can contribute to nonpoint-source water pollution. Livestock producers must be concerned with preventing animal wastes from reaching water bodies; crop producers are faced with soil erosion and sedimentation as their main concern.

Fertilizers, pesticides, chemicals, wastes and sediment may be carried into surface waters by runoff or seep into groundwaters when improperly managed. Noticeable effects of these pollutants include nutrient enrichment which causes algal blooms, fish kills resulting from chemical poisoning or reduced oxygen levels, and smothering of aquatic organisms by sediment.

Best Management Practices

Virginia has chosen to approach the problem of nonpoint-source pollution through voluntary programs and education of its citizens. Producers are encouraged to adopt *Best Management Practices,* often called *BMPs*. BMPs are sound, common-sense conservation practices that will enable improved water quality to be realized. BMPs, which include management, structural, and agronomic measures, take into account existing operations so that productivity is maintained, and even enhanced in some cases.

Runoff from Irrigation

Irrigators encounter the same nonpoint-source pollution problems that all crop producers have. In sprinkler irrigation, which accounts for nearly all of the irrigated acreage in Virginia, irrigators are faced with additional nonpoint-source pollution potential due to the irrigation itself (Figure 1).

Figure 1

While irrigators can only make limited preparations to control storm runoff, they can take positive measures to prevent irrigation from contributing to nonpoint-source pollution. The impact of falling irrigation water, like rainfall, dislodges soil particles. If the water is applied at a rate exceeding the soil's infiltration rate, or if more water is applied than the soil can contain, the resulting runoff can carry the dislodged soil particles away (Figure 2). If the excess application continues, the quantity and velocity of runoff increases to provide sufficient energy for dislodging and transporting additional soil particles. Uncontrolled, runoff cuts rills and then gullies as it carries away valuable topsoil.

In addition to creating water pollution problems due to sedimentation, nutrient enrichment, and chemical poisoning, irrigation runoff represents wasted water and energy.

Another factor to be considered in addition to proper application of water is the degree and length of slope. Steeper slopes increase the velocity of runoff; long slopes allow larger quantities of water to accumulate. Reducing the

Figure 2

quantity and velocity of runoff is a basic principle of erosion control. This can be accomplished by utilizing appropriate combinations of agronomic and structural BMPs.

The physical properties and condition of the soil will also influence the extent of soil erosion. Although soil type cannot be changed, careful cultural practices that promote good soil structure can increase erosion resistance. Fine textured soils are particularly susceptible to runoff and erosion because of limited infiltration and seepage rates. Sandy soils, on the other hand, are vulnerable to nutrients and chemicals being leached into groundwater because they have considerably higher seepage rates and lower water holding capacity.

Soil cover also affects the degree of runoff and erosion that may occur. Cover protects the soil by reducing the impact of falling irrigation or raindrops and by the slowing of runoff velocity. Cover may also increase infiltration capacity and improve soil structure.

Design BMPs

The design of the irrigation system can have a significant effect on the potential for nonpoint-source pollution as well as operating efficiency and costs. One of the first considerations when selecting an irrigation system should be its adaptability to the soil and terrain. For example, because of high application rates, low-pressure center-pivots are best suited to flat terrain and soils with high infiltration rates (Figure 3). Higher-pressure center-pivots, on the other hand, may be adaptable to rolling terrain because of lower application rates.

Because of high application rates and the relatively large water droplet sizes associated with big-gun irrigation, the erosive potential is high. Therefore, these systems are most suited to sandy soils and flat terrain where runoff potential is less.

Portable pipe and solid-set sprinkler-system design is adaptable enough to accommodate a wide range of soil conditions and terrain. The right combination of pipe spacing, sprinkler heads, and pumping capacity can limit the runoff-producing potential of the system.

Trickle and other low-volume systems are particularly well suited to steeper slopes and heavier soils since runoff is practically eliminated. Because of high water-use efficiency, these systems are ideal where water supplies are limited and runoff potential is high.

It is the responsibility of the irrigation system designer to select an appropriate system to meet the needs of the crop and to consider soil and water conservation. Application rates are, for the most part, set by this design. Therefore, if the design application rate exceeds the existing infiltration rate of the soil, runoff will occur. Structural changes can be made after installation of a system to alter application rates. An example of this is the replacement of sprinkler heads and possibly the pumping unit. However, these modifications require redesigning the system and are always expensive.

Figure 3

Figure 4

Relocating systems to field and crop conditions different than those for which they were designed can often lead to runoff problems. An irrigation designer or consultant should be contacted when buying a used system or relocating one to assure that its design application rate is appropriate for the new location. A consultant should also be contacted when there is excessive runoff from an existing system (Figure 4).

Management BMPs

Conscientious management of both the system and the irrigation water is as important in pollution control as proper design. In addition, good management almost always translates into water and energy savings, thereby increasing productivity per dollar invested.

System Management

Producers should develop a familiarity with their systems in order to insure proper and efficient operation. Periodic observation and inspection of the system, as well as a regular maintenance program, will establish this familiarity and identify problems (Figure 5).

The amount of water applied should be determined by averaging the depth of water collected in several rain gauges or straight-sided cans that have been distributed throughout the irrigated field. This information enables the producer to verify that the expected amount of water is being applied.

In the case of self-propelled systems, such as center-pivots and travelling guns, the travel speed should be checked periodically. For example, the speed of a hose-tow travelling gun should be observed at the beginning, middle, and near the end of the travel lane to assure proper speed compensation as the hose is wound on the drum (Figure 6).

Periodic inspection of pumps, controls, pipes, and sprinklers is also advisable (Figure 7). When these components wear out, design discharge may be affected. Maintaining records of fuel consumption and pressure gauge readings will also help operators foresee developing problems. Prompt attention to problems such as line breaks and leaking seals will prevent needless soil erosion. Of course, nothing can substitute for regularly scheduled maintenance.

Properly maintained equipment is not, however, all that must be considered to assure proper application. For example, if the big gun on a traveller is left operating too long while stationary, such as at the end of its travel lane, this area will receive excessive amounts of water. Simple devices, such as shut-off timers, are available to eliminate this type of problem.

Operators of big guns should also be aware that a distribution pattern smaller than a full circle will proportionately increase the rate of water applied. For example, the application rate is doubled when irrigating with a half-circle rather than a full-circle pattern. A partial-circle pattern should, therefore, be used only where necessary.

Nighttime irrigation can result in substantially higher irrigation efficiencies due to reduced evaporation. For example, a sprinkler system which operates at 70% efficiency during the day may operate as high as 90% efficiency at night. Therefore, a larger amount of water is available for runoff.

Figure 5

Figure 6

Figure 7

In situations where infiltration rates are restricted, the amount of water needed may be applied in two applications. This may require making two passes with a self-propelled system, or providing a delay period between two separate applications with a stationary system.

Water Management

The primary objective of water management is to apply the right amount of water at the right time while maintaining the higher yields attributable to irrigation. Irrigation scheduling can result in significant savings in irrigation time, labor, and water. It can also translate into a direct savings of energy and maintenance costs and extended life, through reduced use, of the irrigation system. By carefully managing the amount of water applied, leaching of nutrients and erosion can be reduced. Plants susceptible to disease caused by excessive moisture may also benefit. In other words, irrigation scheduling increases profits and, at the same time, contributes to nonpoint-source pollution abatement.

Proper irrigation scheduling requires monitoring the soil moisture conditions. In addition, it is important to know the waterholding capacity of the soil in determining the amount of water to be applied.

Attention should also be given to how the water needs of the crop depend upon the stage of growth. For example, corn is not as susceptible to moisture stress during its early vegetative stage as it is during tasseling and silking.

Impending weather conditions should, of course, be considered. In order to provide sufficient storage capacity in the event that rainfall follows irrigation, the soil should not be completely saturated.

Plant wilting has been used extensively for irrigation scheduling in the past, however, it has been shown that potential yields may have already been reduced before reaching this point. Traditional methods, such as "soil feel" and soil probe techniques, can be used with reasonable success after the producer has gained considerable experience.

Three modern techniques for irrigation scheduling are recommended for Virginia's conditions. These include the use of tensiometers, evaporation pans, and moisture accounting methods. It is further suggested that two methods be used concurrently as checks on each other.

1) The tensiometer is an instrument which measures the increased tension, or suction, in the soil as it dries (Figure 8). Virginia Cooperative Extension Service (VCES) agents can help producers interpret readings in terms of plant-available water.

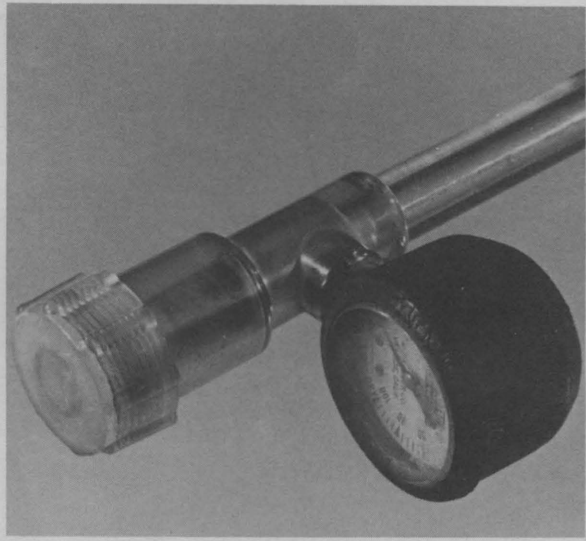

Figure 8

2) The water level in an evaporation pan fluctuates with atmospheric evaporation, rainfall, and irrigation. When the water level drops to a pre-determined point, depending upon the soil and crop, irrigation should begin.

3) The moisture accounting method, also referred to as the bookkeeping or checkbook method, requires that measurements of rainfall and irrigation, and estimates of evapotranspiration, be added and subtracted; and a soil moisture balance be maintained. When a predetermined water level is reached, irrigation should begin. This method is suitable for programming on a farm computer.

Agronomic and Structural BMPs

In addition to proper initial design, maintenance, and management of the irrigation system, producers can sometimes benefit from utilizing conservation cropping practices such as contour tillage and no-till planting. Contour tillage reduces runoff velocity and increases infiltration, thereby reducing runoff. In addition to runoff control, no-till cropping also offers considerable savings in time and energy; this translates into higher profits (Figure 9). Reduced runoff due to conservation cropping means higher irrigation water efficiency, less nutrients and chemicals lost, and, of course, reduced soil erosion.

Diversions may be used in conjunction with other BMPs when runoff from areas above cropped fields is causing erosion. The diversion, constructed at the upper edge of the cropped field, intercepts and channels erosive runoff around

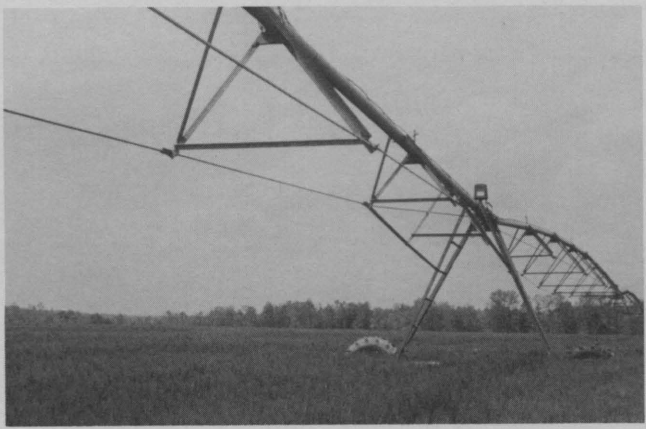

Figure 9

the field. Producers can also utilize grassed filter strips, grassed waterways, terraces, and drop structures to help control erosion problems.

Carefully selected and implemented, combinations of management, agronomic, and structural BMPs offer producers the means to increase or, at least, maintain productivity while contributing to improved water quality in Virginia.

Fertigation and Chemigation BMPs

Producers can utilize many types of irrigation systems to safely apply fertilizers and chemicals to their crops (Figure 10). A few guidelines will help assure that these materials do not become pollutants.

1) Injection systems should be designed to prevent any possibility of contaminating water supplies in the event of equipment malfunction. This includes the use of appropriate check valves and anti-siphon devices to prevent backflow of fertilizer and chemicals into water bodies.

2) Chemicals should be mixed and injected in areas that are located well away from water bodies, and provisions should be made to

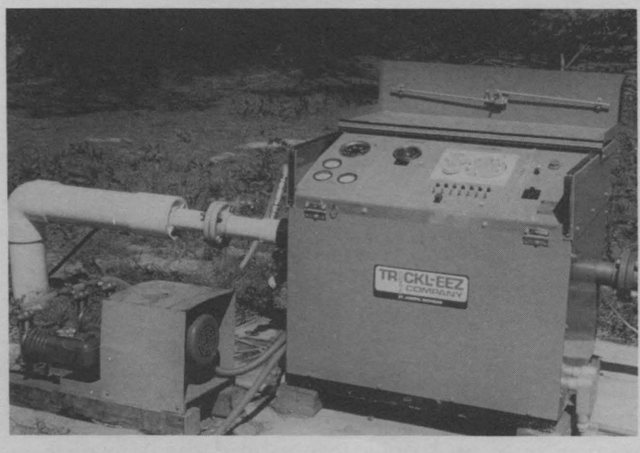

Figure 10

contain any spills which might occur. Likewise, care should also be taken when fueling combustion-type power units near water supplies.

3) Chemical application should be avoided when wind could carry nutrients or chemicals into streams, lakes, or the irrigation pond.

4) In addition to proper handling and storage practices, producers should give special attention to calibrating injection equipment to assure that intended rates are applied to the crop.

5) Do not exceed the recommended rates of either chemicals or water; excessive amounts waste money and can easily be carried with runoff or groundwater seepage into water sources.

6) Weather conditions and soil moisture status should be considered whether the irrigation system or conventional methods are used to apply fertilizers and chemicals. In most cases, applications soon before or shortly after rainfall or irrigation can greatly increase the potential for nonpoint-source pollution.

Other Concerns

Additional uses for irrigation systems, such as frost protection, turf irrigation, and waste disposal can also contribute to nonpoint-source pollution. However, these uses involve additional design and management concerns which are beyond the scope of this publication.

Conclusion

If Virginia's *voluntary* approach to nonpoint-source pollution is to be successful, all of us must look at our operations and ask, "Has my production contributed to nonpoint pollution?" Your local VCES agent can help you answer this question.

Technical assistance for the planning, design, and implementation of Best Management Practices is available from your District Conservationist at your local Soil and Water Conservation District office and from the Soil Conservation Service.

Now is the time to develop a feasible plan to preserve water quality for future generations of Virginians. It is only through the concern and actions of *all* Virginia citizens, including irrigators, that a reduction in nonpoint-source pollution and improved water quality can become a reality.

Recommended Reading
These publications in the BMP Series may be obtained from your Extension Agent:

Best Management Practices in Agriculture and Forestry, 4WCB1, January 1980;

Best Management Practices for Row Crop Agriculture, 4WCB3, June 1980;

Best Management Practices for Beef and Dairy Production, 4WCB4, July 1980;

Best Management Practices for Swine Operations, 4WCB5, November 1980;

Best Management Practices for Tobacco Production, 4WCB6, January 1981;

Conservation Tillage—A Best Management Practice, 4WCB7, January 1981;

Terraces—A Best Management Practice, 390-408, October 1981;

Integrated Pest Management—A Best Management Practice, 390-409, February 1982;

Best Management Practices for Horticulture, 390-410, November 1982.

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