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RESERVOIR TILLAGE FOR CONTROLLING RUNOFF AND SAVING ENERGY

Background

As energy costs have risen in recent years, sprinkler irrigation equipment has been designed to apply water at lower pressures. Some low pressure devices have been developed for use with set-move systems, but the most popular application has been on self-propelled systems such as center-pivot and linearmove systems.

Although low pressure sprinkler systems reduce irrigation pumping energy requirements in most cases, their use can greatly increase the potential for runoff. Since the pattern diameter of low pressure sprinklers is less than that of high pressure sprinklers, water is applied over a smaller area. This increases the application rate, and can often exceed the soil water intake rate. (These relationships are explained in the BPA Irrigation Energy Efficiency sheet on "Irrigation Runoff Control Strategies.")

If the water application rate exceeds the intake rate, surface ponding can occur. This surface water can move within the field from high areas to low areas. Runoff or wet and dry areas provide visual evidence of surface water movement, which results in crop variability and loss in crop production. These losses can be reduced by increasing intake rates and/or surface storage capacity of the soil so that all water is retained where it is applied.

Reservoir Tillage

Several types of tillage implements have been developed to form basins in row crops and small grains. Most machines use one of two basic methods for creating the basins. One method (basin tillage) uses a shovel type implement to drag soil a short distance and deposit it in a pile to alternately create small dams and basins. The basin length usually ranges from 2 to 6 feet, and the intake rate of the soil is not altered.

The second method (reservoir tillage) uses spades mounted on wheels to punch holes in the soil surface. This punching action creates small subsurface reservoirs usually spaced at 2 to 3 feet. The reservoir tillage machine usually incorporates a ripper that loosens the soil prior to punching the holes (Figure 1).

A major advantage of reservoir tillage is that it can be used effectively on slopes greater than 5 percent. Loosening the soil, coupled with the close spacing of the subsurface reservoirs, enhances infiltration and provides surface and subsurface storage for applied irrigation water -- and precipitation.

Runoff Losses Under Conventional and Reservoir Tillage

Research investigations have been conducted over several irrigation seasons to determine the effectiveness of reservoir tillage in reducing water movement within irrigated fields and runoff from these fields. Plots were established on different irrigated fields in Idaho, Oregon and Washington. All fields were irrigated using center-pivot irrigation systems. The plots were set up under the outer spans of the center-pivot systems where the application rates were highest with the greatest runoff potential.

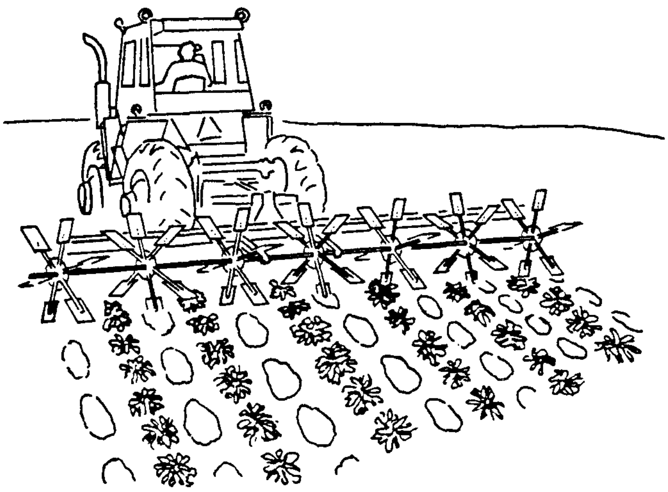

Figure 1. Reservoir tillage creates basins or pits to hold water in place, allowing it to infiltrate into the soil, thus preventing runoff.

The data in Table 1 are from sample plots that are representative of many fields studied. The effects of reservoir tillage on runoff are shown. Runoff from conventionally tilled plots without reservoir tillage was greater than from those plots with reservoir tillage. The amount of runoff from reservoir tilled plots was generally less than 5 percent of the applied water. The runoff from plots is an indication of water movement within the fields as well as water lost as runoff from the fields. The data indicate that the amount of runoff is quite independent of the crop. It is affected more by soil, slope and management. Crops with narrow row spacing will tend to have less runoff with reservoir tillage since each reservoir has to retain less water because the rows are closer together.

Table 1. Runoff and crop yields for plots with conventional tillage (CT) and reservoir tillage (RT).
<u>NOTE</u>: Plots with the same numbers were located in the same field with different slopes.

No.	Crop	Soil	Slope (%)	Percent runoff CT	Percent runoff RT	Yield (T/a) CT	Yield (T/a) RT
1a	Corn	Sandy loam	4	7	<1	5.2	5.4
1b	Corn	Sandy loam	6	21	<2	5.1	5.4
2a	Potatoes	Sand	12	15	2	30.9	32.7
2b	Potatoes	Sand	0	7	<1	33	25.9
3	Potatoes	Silt loam	0	<1	0	21.4	22.0
4a	Potatoes	Silt loam	1	12	2	17.5	17.6
4b	Potatoes	Silt loam	8	20	17	18.5	18.5
5	Wheat	Silt loam	5	22	4	2.3	2.8

For reservoir tillage to be most effective, the reservoirs must remain intact throughout the entire irrigation season. It is important that reservoir tillage be done when soil moisture content is at the proper level --the soil should not be too wet nor too dry. This aspect is not so critical for sandy soils as for finer textured soils. One reason for the large amount of runoff from the plots at site 4b is that reservoir tillage was done when the silt loam soil was quite dry. The soil forming the small reservoirs was not compacted properly, and when water was applied, the reservoirs did not maintain their shape. In another instance, there was subsurface water movement in the ripper mark connecting the reservoirs.

Soil water levels were monitored in the fields studied, and results from one corn field are shown in Figure 2. The amount of water in the soil was greater under reservoir tillage throughout the irrigation season. This shows that more of the water applied by the sprinkler system was stored in the root zone available for plant use.

Crop Yields Under Conventional and Reservoir Tillage

Crop yields were obtained from the fields studied. (Table 1). Generally, yields under reservoir tillage were equal to or greater than the yields under conventional tillage. The greater soil moisture levels associated with reservoir tillage reduced moisture stress on growing crops and resulted in greater yields.

Another factor to consider is more uniform crop yield and quality. Since there is less water movement from high to low spots within a field, crop quality will be more uniform. This factor is more important for crops such as potatoes that are sensitive to proper soil water levels.

As with any cultivation practice, the timing of reservoir tillage relative to crop growth stage is important. It is generally recommended to delay reservoir tillage until the crop covers 30-50% of the soil surface. However, there can be some root pruning and other damage if the reservoir tillage is done too late. On small grains, reservoir tillage should be done at planting or shortly thereafter. If the grain has sprouted, serious stand reduction can occur.

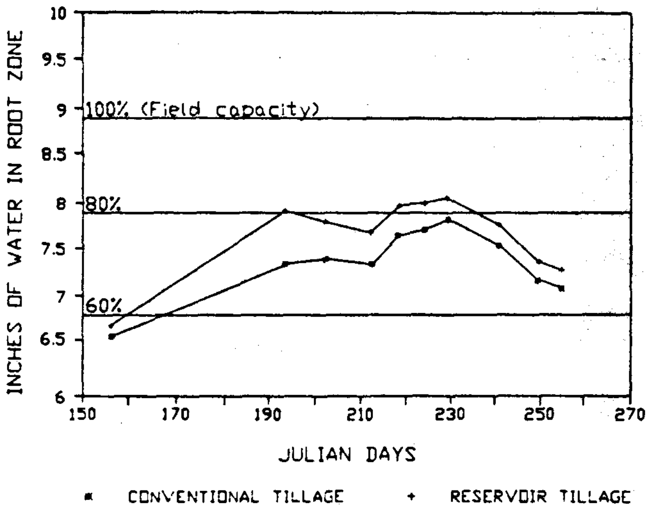

Figure 2. Soil water levels for conventional and reservoir tillage.

Energy Savings From Using Reservoir Tillage

The amount of energy required for irrigation pumping depends on several factors including pumping lift, pumping plant efficiency, irrigation system efficiency and crop water use. Energy savings can result from the efficient application of irrigation water. Less pumping is required with resulting energy savings.

From the fields studied, the potential energy savings from using reservoir tillage range from 1 percent to more than 30 percent. The amount of savings depends upon both the amount of runoff experienced using conventional tillage and the effectiveness of reservoir tillage. Examples of energy savings for two corn fields and two potato fields are shown in Table 2.

Table 2. Potential energy savings associated with reservoir tillage low pressure sprinkler irrigation systems.

		----- Percent Energy Savings ------		
No.	Crop	Reservoir Tillage	Reduced Pressure	Total
1	Corn	14	9	23
2	Corn	3	15	18
3	Potatoes	19	11	30
4	Potatoes	1	40	41

For the examples shown in Table 2, the potential energy savings associated with reservoir tillage was substantial for fields 1 and 3. The main reason for the small potential savings for fields 2 and 4 is because there was minimal runoff under conventional tillage. Field 4 had essentially no slope.

The potential energy savings are also shown for reduced operating pressure. The pumping lift for field 1 is quite large, and reservoir tillage has more potential in reducing energy use than a low pressure sprinkler system. The opposite is true for field number 4 which has minimal slope and a small pumping lift. The numbers in Table 2 indicate that for most cases reservoir tillage is an effective practice for reducing energy requirements along with low pressure irrigation systems.

The value of the energy savings must be weighed against the cost of reservoir tillage that includes the costs of leasing or owning and operating equipment.

Summary

- Reservoir tillage is effective in reducing water runoff from irrigated fields and water movement within fields.
- Crop yields are generally greater with reservoir tillage with more uniform yield and quality over a field.
- It is important that reservoir tillage be done when soil moisture conditions are suitable for forming stable reservoirs that will remain intact over the irrigation season.
- Use of reservoir tillage has the potential for saving pumping energy especially when using low pressure sprinkler irrigation systems with greater application rates.

The merits of reservoir tillage should be determined for each location and application. It is important to consider the soil, slope, crop and other management factors along with the costs of reservoir tillage and energy savings.

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