# STRAW MULCH APPLICATION TO FURROW IRRIGATED CARROTS
Analysis of irrigation stream advance, soil wetting front and sediment in runoff water.

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**Abstract**

**A 20-acre carrot field was used to test straw-mulching of irrigation furrows to control erosion. Straw mulch was applied at a rate of 960 lb/acre, with the exception of a small control section. The first furrow irrigation lasted for 24 hours with an inflow rate of 7.3 gal/min per furrow. The average water advancement for the control and mulched sections was 3.65 ft/min and 1.32 ft/min, respectively. The water advance time dictated the infiltration rate and therefore the time needed for the complete water saturation of the furrow. The advance of the wetting front was considered complete when the soil became saturated at a depth of 12 inches. Complete saturation took place within 4 hours after initial wetting while the control furrows took more than 8 hours to completely saturate. Erosion was greatly reduced by the mulched treatment. Soil loss dropped from 10.3 g/L (12.7 tons soil/acre ft water) in the control plot to 0.365 g/L (0.45 tons/acre ft) in the mulched plot. Therefore, the application of straw mulch in this furrow irrigation system greatly increased the rate of water infiltration and dramatically reduced the amount of soil loss due to erosion. Yield of carrot seed was unaffected by straw mulching. Straw-mulching may require the irrigator to manage differently, and several suggestions are given that may prove helpful.**

## Introduction

In this age of environmental consciousness, many aspects of today's modern farming practices are being reviewed and improved. Furrow irrigation, which may waste water, and contribute to downstream pollution by adding soil sediment and chemicals, is the focus of this study. Furrow irrigation on moderate to severe slopes can dramatically increase soil erosion and decrease water use efficiency. One technique that has been shown to improve these factors is the application of straw mulch to the irrigation furrows. Miller and Arstand (1983) at Prosser, Washington, showed that the application of small amounts of plant residue in irrigation furrows reduced erosion and lowered the turbidity of the runoff water. Berg (1984) also showed that application of small amounts of straw into irrigation furrows could increase water infiltration and decrease soil erosion on furrow-irrigated land near Kimberly, Idaho. Straw-mulching of furrows, is gaining widespread acceptance in Malheur County, Oregon, where tests have shown its effectiveness at reducing erosion.

The objective of this study was to test the effectiveness of straw mulching to reduce erosion and increase water infiltration in central Oregon. Irrigation stream advance and soil sediment in runoff water were tested, along with the wetting front of the soil water into the bed. An experiment was designed to determine the effects of a wheat straw mulch application on soil erosion, water infiltration, water runoff rate, and yield.

## Materials and Methods

The study was conducted on the Jack Ickler farm located just outside Culver, Oregon. The soil consisted of a Cullius loam with a 2.05 percent slope. The soil is shallow, 10 to 20 inches to bedrock, and is well drained. The available water capacity is about 2 inches.

A 20-acre field was bedded and planted with carrots for a seed crop. In May, wheat straw was applied to the whole field at a rate of 960 lb/a, with the exception of a small control plot that received no straw. The control plot was 24 ft wide (eight rows) and 1,200 ft long. Straw was applied with a commercially-available, straw-mulching machine that takes bales of wheat straw and applies them to furrows. The carrot crop was sprinkler irrigated until the height of the plants, about 1 foot, made this practice no longer feasible. Sprinkler irrigation was then replaced by furrow irrigation, which was used until seed harvest. Measurements of irrigation were taken during the first furrow irrigation.

Prior to the first furrow irrigation, markers were placed at 50 foot intervals to assist in measuring the water advance rate. Furrow dams were placed at the end of the furrows to measure the water outflow rate. WATERMARK soil moisture sensors (Model 200) were placed 50 feet from the head of the field in both control and mulched sections at depths of 3, 6, 9 inches, below the furrow bottom, and 3, 6, 9, and 12 inches in the beds. The WATERMARK sensors were used to determine the location of the wetting front in time of both treatments. Soil erosion was determined by collecting several water samples and correlating the results with runoff rates.

Yield of carrot seed was determined on the control plot and two mulched plots on each side of the control. No statistics were calculated because the study was unreplicated.

## Results and Discussion

<u>Irrigation stream advance</u>

After a few minutes of irrigation, several differences between the mulched and control sections could be observed. The first obvious difference between the two sections was the rate of water advancement in the furrows (Fig. 1). Irrigation in the control plot reached the end of the field (1,300 ft) in less than 6 hours. Irrigation in the mulched plot took more than 12 hours to reach the end.

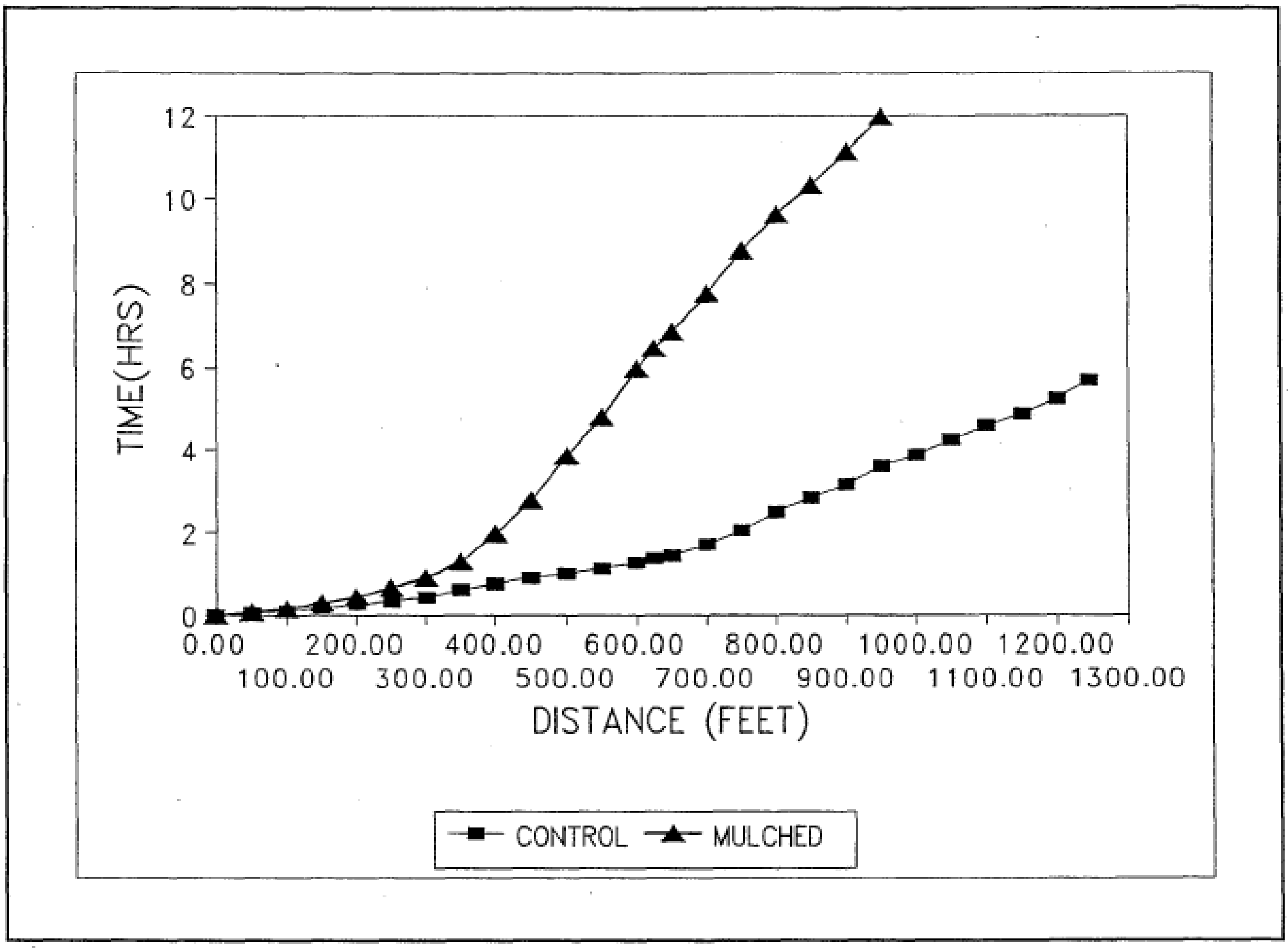


**Figure 1.** Water advance for control and mulched furrows, Madras, OR,

Christiansen et al. (1966) pointed out the relationship the water stream advance and the infiltration rate (all other factors being equal), and developed equations to relate the two. DeTar's (1989) modification of the Christiansen method of determining average infiltration rates, uses the stream advance function in surface-irrigated plots to obtain the infiltration function. Using the DeTar modification, the infiltration equations were

$$I=0.058T^{0.614} \quad (1)$$

and

$$I=0.026T^{0.975} \quad (2)$$

for the control and mulched sections respectively. Using these infiltration functions, one is able to obtain an average of depth infiltrated over time. The amount of water that infiltrates into the mulched treatment after 4 hours is twice the amount of the nonmulched treatment. Longer infiltration times result in greater differences in water intake between the treatments.

The intake equation (2) for the mulched furrow is approximately linear, since the exponent 0.975 1. Theory of soil water infiltration, which is beyond the scope of this report, suggests that the intake rate may drop sharply after the soil is entirely wet. This would imply that water is not being applied in excess in the mulched treatment. Additional research should address the question of the whether excess irrigation water is, in fact, being applied to the mulched treatment.

Wetting front advance

As we have seen, the infiltration rate of the mulched furrow was greater than that of the control furrow. This information means that less irrigation time is needed for complete saturation of the furrow slice. This fact can be seen in the soil saturation data measured by the WATERMARK sensors. Complete saturation of the mulched furrow took place within 4 hours after initial irrigation, whereas the nonmulched furrow needed more than 8 hours for full saturation.

A possible reason for the rapid saturation of the 9 and 12 inch sensors is a duripan layer at the 10 to 12 inch depth that would direct water flow horizontally after it reached the pan. Water flowing laterally from the furrow stream would also tend to quickly saturate the deeper sensors. Still, with this in mind, saturation of the mulched furrow mound (MM) happened at a much faster rate than the control mound (CM). A lower saturation time was dictated by the increased infiltration rate resulting from the mulch application.

Sediment in runoff water

Water samples taken during the first irrigation showed an average sediment concentration of 10.3 g soil/L water for the non-mulched control plot, and 0.365 g soil/L for the mulched treatment, which was less than 4 percent of the control. The results were startling to the farmer, who had to clean his tail ditch only in the area where he had not mulched.

Yield

Yield statistics are shown in Table 1. The straw-mulch treatment had 3.2 percent greater yield than the control, which is not large enough to suggest that there was any yield benefit. The germination percentages were essentially equal for both treatments.

Table 1. Yield data, 'cider Farm, Culver, OR, 1991

| | Straw Mulch | Control |
|---|---|---|
| | --lb/a-- | --lb/a-- |
| Yield uncleaned | 1937 | 2007 |
| Yield cleaned | 585 | 567 |
| Germination percentage | -- %-- | -- %-- |
| Large seeds | 95 | 95 |
| Medium seeds | 98 | 97 |
| Small seeds | 95 | 95 |

Implications for irrigation management

If switching to a straw-mulched furrow, the irrigations will need to be managed differently than before. The greater infiltration rate of the mulched furrows means that the irrigation can be stopped soon after water reaches the end of the field, thereby reducing runoff. Due to the high intake rate, it is possible that the soil at the head end may receive excess water that could leach nitrate from the soil. If that is the case, further management improvements could combat the leaching, e.g. irrigating alternate furrows, or reducing the amount of straw in the head end of the field to speed the furrow advance in that area. Surge irrigation could also be used in conjunction with straw-mulching to reduce infiltration rate and leaching while controlling erosion. Field research could test the ability of these methods to modify infiltration under the straw-mulching system, but the irrigator will need to observe intake rates as they occur in the field and adjust his management accordingly.

## References


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