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Firming Irrigation Furrows to Improve Irrigation Performance

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This NebGuide describes how using a furrow firming wheel improves furrow irrigation performance.

Approximately 40 percent of the irrigated acres in Nebraska are furrow-irrigated. Higher pumping costs, water restrictions and water shortages are all factors encouraging efficiency-improving irrigation practices. Generally, reduced application efficiency with furrow irrigation occurs because of runoff or deep percolation. Although hard to eliminate, runoff can be controlled by tailwater reuse systems, changing furrow stream size, or changing irrigation set time.

Deep percolation is the loss of water below the root zone. The amount of deep percolation caused by irrigation is difficult to estimate unless irrigation application is measured or the soil water content is monitored. Deep percolation reduces irrigation efficiency and increases pumping costs. In addition, chemicals applied to the soil surface to control pests and improve production can leach below the root zone and into the groundwater.

Uniform application of water using furrow irrigation is difficult to achieve. As water advances down a field, the opportunity time, or the time water has to infiltrate the soil, is greater at the upper end of the field than the lower. For example, if water advance in the furrows takes six hours to reach the end of a field, and total set time is 12 hours, then the opportunity time is twice as long at the head of the field.

Non-uniform furrow irrigation, a primary cause of deep percolation, is usually more pronounced during the first irrigation of the season. Early in the season, soil conditions are loose because the soil has not yet consolidated due to irrigation or rainfall. Cultivation and furrow construction loosen the soil further and encourage surface soil water evaporation. In addition, root activity early in the growing season depletes soil water in the top layers of the soil. All of these conditions can result in dry, loose soil making irrigation difficult. If moving water down the field is difficult, nonuniform irrigation will result, causing deep percolation of water below the root zone, particularly at the head end of the field.

When faced with difficult furrow irrigation conditions, several alternatives are available. Furrow stream size can be increased to improve irrigation uniformity by reducing advance time and allowing a more equal amount of water to be applied at the top and bottom of a field. Increased runoff and the potential for soil erosion is the disadvantage of large stream size.

Another alternative is to extend the irrigation set time to allow water movement down the furrow to the end of the field. However, when set times are increased beyond 12 hours, the opportunity for water to infiltrate at the top of the field increases and deep percolation can result. Any process allowing water to advance in a furrow and reach the end of the field faster will help improve water distribution and obtain more uniform irrigation.

Tractor wheel traffic during planting and cultivation may compact the soil in some furrows, reducing water infiltration rate. It is easy to see which furrows are hard (tractor track) and soft (no tractor track) during irrigation. Normally, the hard furrow requires less water and allows water to move down the field faster. With the soft furrow, it is difficult to get water to the end of the field even though additional water is used.

Because equipment for planting and cultivation has become larger, the number of soft furrows has increased accordingly. For example, if irrigating every other row in a 12-row planting and cultivation system, there could be four soft furrows and only two hard furrows. This occurs even with the use of dual tractor tires. If management calls for every furrow to be irrigated, the number of soft rows to hard rows will increase even more.

Another factor which influences furrow infiltration rate is the tillage system used. Reduced tillage and no-till systems have been shown to reduce production costs and maintain crop yield. However, as tillage is reduced, soil often becomes friable, allowing water to more easily infiltrate the soil. High infiltration rates are desired under center pivot irrigation systems, and even under furrow irrigation systems, to trap more precipitation. Yet with furrow irrigation systems, higher infiltration rates can result in more difficulty advancing water to the end of a field.

Firming Furrows

When soil infiltration rate is high and furrow advance is slow, some producers will pack soft furrows to reduce the

Figure 1. Eversman v-wheel used in Nebraska study.

infiltration rate. Commonly, the method is to drive tractors with no implement attached in the furrows to compact the soil and aid in water advance. Using a tractor can, however, result in deep compaction which can influence plant root development later in the season.

Furrow firming, on the other hand, uses an implement to firm the top 3-4 inches of soil in the furrow without compacting soil at a depth that might hinder root development.

In some locations, the soil infiltration rate is low enough that furrow firming would not be advisable. Heavy, tight soils, or soils prepared under wet conditions, might need field operations to increase the infiltration rate. If the first irrigation is difficult, and it is hard to get water to the end of the field, furrow firming might be one alternative available to improve irrigation practices.

Comparison of Conventional and Firmed Furrows

In the following two studies, furrow firming was accomplished using Eversman[1] v-shaped wheels. In a Wyoming study, Eversman wheels 14 inches in diameter and 8 inches wide were used. The Nebraska study used Eversman wheels 18 inches in diameter and 12 inches wide, *Figure 1*. In both studies, the wheels followed a ditcher for opening and shaping the furrow. The wheels were mounted to allow for independent motion of the packing wheel in relation to the furrow opening process. Tractor suitcase weights were added to each packer wheel assembly.

Wyoming Study

In Wyoming, a study was conducted to determine the effect of furrow firming on the advance of water down a furrow. *Figures 2* and *3* show the results of that study. Furrows were firmed using v-shaped wheels in 1982 and 1983. *Figure 2* is a comparison of furrows conventionally prepared and furrows firmed using the v-wheel. Total weight of the v-wheel was 170 lb with 315 lb of additional suitcase weight. Two conventional-tilled fields and one no-till field were selected. In all cases, water advance was further in the firmed furrow for a given period of time. In the no-till field, water in the firmed furrow advanced more than twice the distance than water in the conventional furrow. Water advance was improved the most in the soft furrows of the conventional fields.

Figure 3 shows the study's second-year result. During this year, the treatment of firming without adding additional weight was included. For both sites, water advance was improved for a given time period when the v-shaped wheel

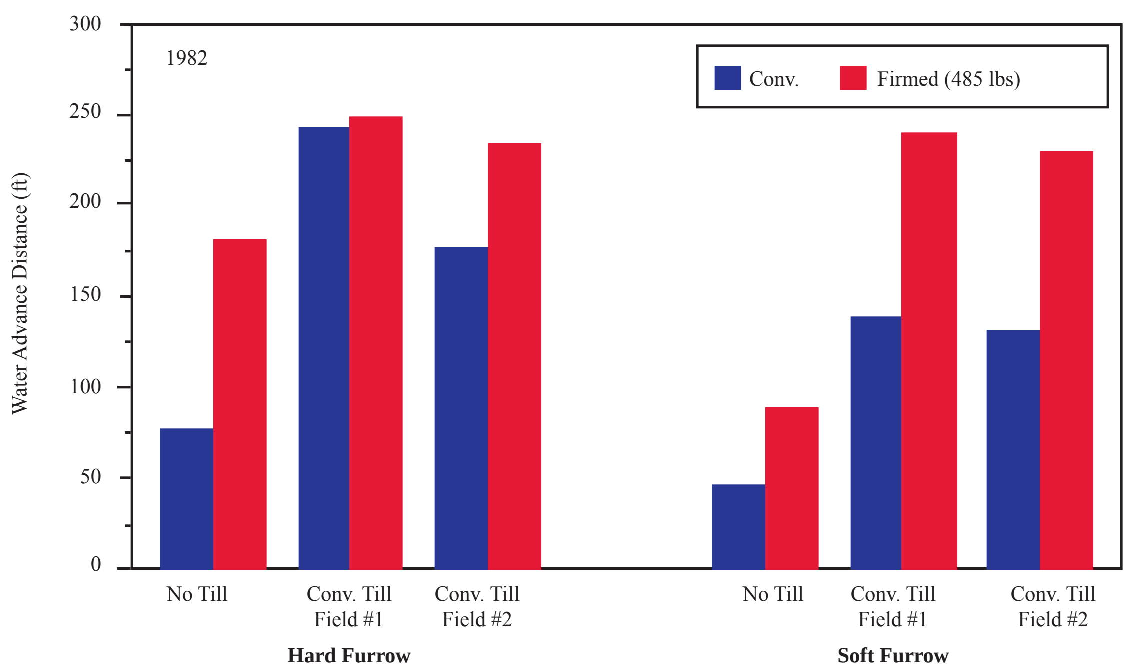

Figure 2. Furrow advance distance in hard and soft furrows for conventionally prepared furrows and furrows firmed with Eversman v-wheel (485 pounds total weight).

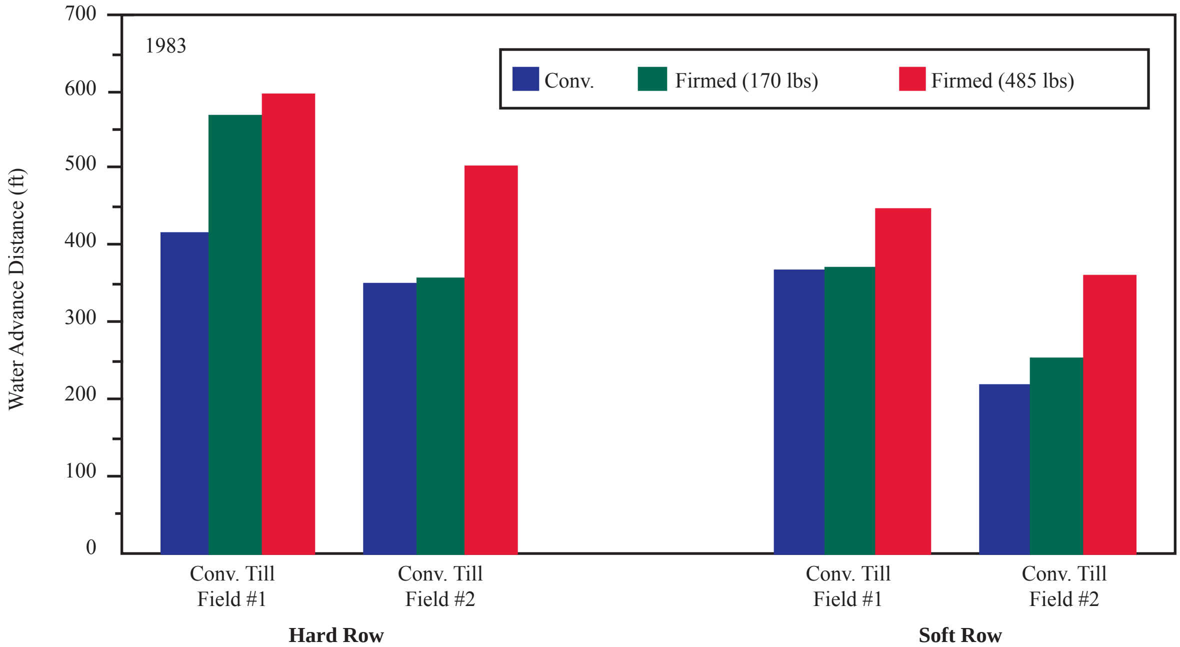

Figure 3. Furrow advance distance in hard and soft furrows for conventionally prepared furrows, furrows firmed with Eversman v-wheel (170 lbs) and furrows firmed with Eversman v-wheel with 485 lbs total weight.

was used both with and without additional weight. A small difference occurred in conventional-tilled field number one between the two firming treatments.

This could mean the construction and shape of the furrow is as important as firming the furrow with additional weight in some situations. However, in other cases firming the furrow without additional weight was not effective in significantly improving water advance. Overall these tests indicate furrow firming reduced the advance time of water to the end of a field.

Nebraska Study

In Nebraska, a similar study measuring the influence of furrow firming was conducted during 1989 and 1990. The study compared conventional irrigation practices with furrow firming and surge irrigation. Furrows were firmed using v-shaped wheels weighing 330 lbs. Surge irrigation, like furrow firming, provides a method to reduce infiltration rate and subsequently reduce advance time to the end of the field.

The results of the Nebraska studies, including 13 test locations across the state, are shown in *Figure 4*. In each case,

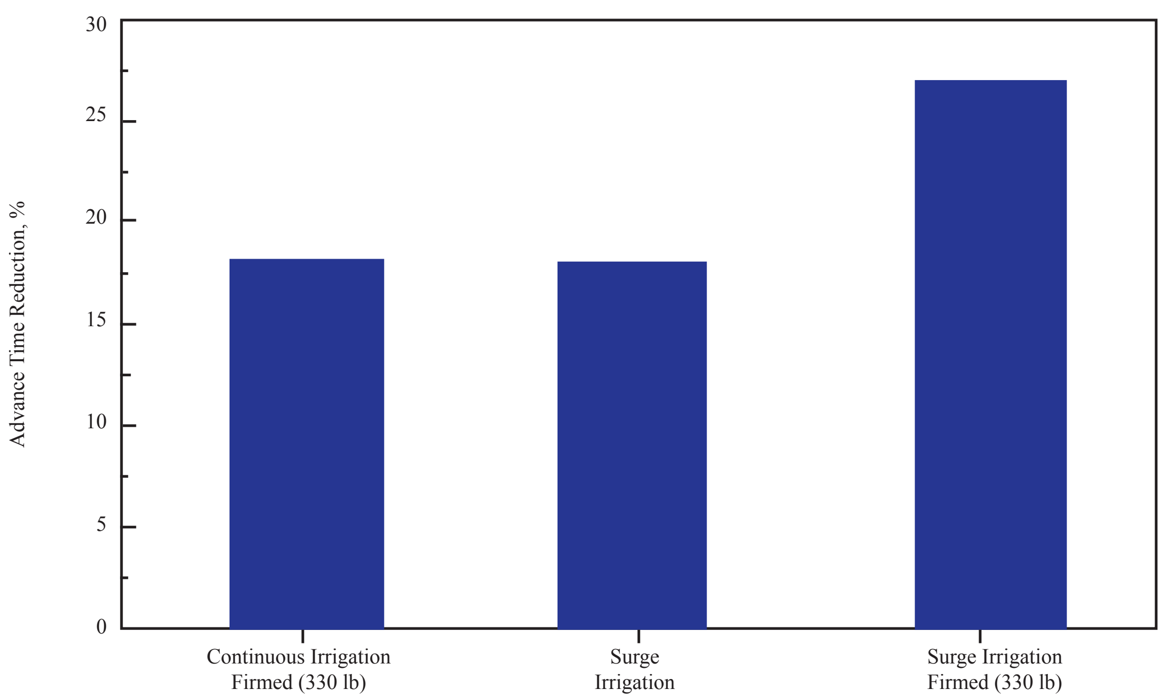

Figure 4. Average furrow advance time reduction as compared to continuous irrigation in a soft furrow for continuous irrigation in a firmed furrow (330 lbs), surge irrigation and surge irrigation in a firmed furrow (330 lbs).

Figure 5. A 12-row furrow opener and firming wheel system.

soft furrows were tested to remove tractor track influence. All treatment results are given in terms of advance time reduction in percent compared to the conventional treatment of continuous irrigation in a soft furrow.

When compared to continuous irrigation, advance time was reduced by 18 percent for either surge irrigation in a soft furrow or continuous irrigation in a firmed furrow. When the two treatments were combined, advance time was reduced by 27 percent compared to continuous irrigation in a soft furrow. These results indicate that either furrow firming or surge irrigation equally reduces furrow advance time, but a greater reduction can be achieved when surge and furrow firming are used together.

In this study, advance times, at all sites were not improved by using furrow firming or surge irrigation. Furrow firming reduced furrow advance time at seven of 13 locations. Surge irrigation reduced furrow advance time at eight of the 13 locations. When furrow firming and surge were combined, the response was similar. The locations with reduced advance times as a result of firming or surging were the same locations showing advance time reductions when firming and surge were combined. These results indicate that if soil conditions are such that neither furrow firming nor surge irrigation help to reduce furrow advance time, a combination of the two operations will not reduce furrow advance times either.

Summary

Firming irrigation furrows results in a smooth, firm, clod-free furrow. *Figure 5* shows a 12-row furrow opener and firming wheel system used by a producer in western Nebraska to reduce infiltration rates and improve water advance time down the furrow. With a given amount of water introduced into a furrow, if the infiltration rate is reduced, then additional water is available to advance further down the furrow. The result is faster advance time to the end of the field, improved water distribution and decreased potential for deep percolation at the head end of the field.

References

Fornstrom, K.J., J.A. Michel, Jr., J. Borrelli, and G.D. Jackson. 1985. Furrow firming for control of irrigation advance rates. TRANSACTIONS of the ASAE 28(2):529-531, 536.

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