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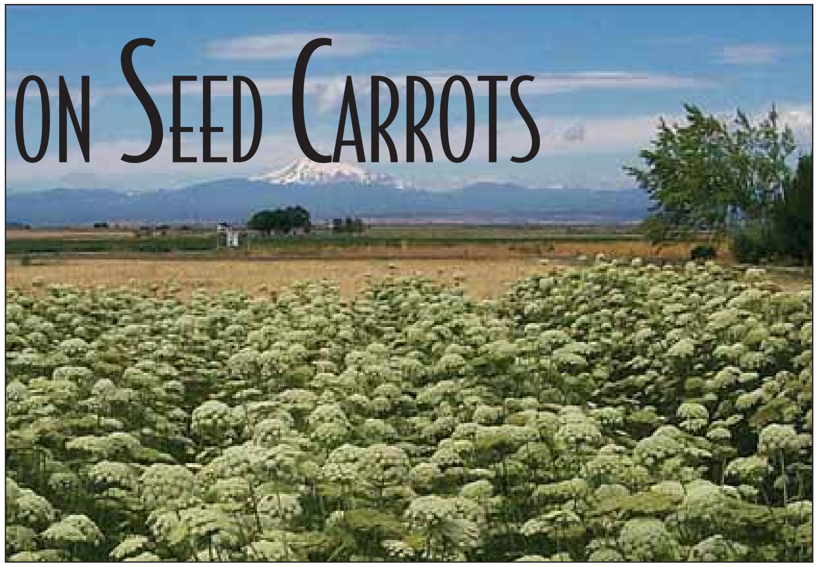
Management Guide for Drip Irrigation on Seed Carrots in Central Oregon



C.E. Weber, M.D. Butler, C.K. Campbell, B.A. Holliday, and J. Klauzer

In 2000 and 2001, research at the Central Oregon Agricultural Research Center in Madras, Oregon evaluated drip irrigation on seed carrots. Benefits included a significant reduction in water usage, increased seed yields, and a decrease in disease.

As a result, drip irrigation was placed in commercial fields in 2002. Drip irrigation is now used in the Culver and Madras regions of central Oregon, with use increasing each year.

Irrigation scheduling and system maintenance are different for drip irrigation than for sprinkler or furrow irrigation. This publication provides local seed carrot growers with information necessary for effective management and utilization of their drip systems.

Drip irrigation system design

The drip systems used in central Oregon consist of sand media filters, layflat hose, and drip tape. Drip systems are specially designed for each field. The irrigation system supplier maps the field using GPS to determine its elevation and dimensions. An irrigation engineer uses this information to design a system to maximize efficiency. Each field is divided into zones, or watering areas. Zones are determined by numerous factors, including field size, topography, soil variation, optimal tape run length, and filter capacity.

The tape is installed 2 to 4 inches beneath the soil. When rows are on 30- or 36-inch centers, the tape is placed 3 to 5 inches from the carrot row. If 24-inch centers are used, the tape commonly is placed down the center of the row, putting it 12 inches from each row. The typical tape flow rate for seed carrots in this area is 0.22 gal/min/100 ft.

When the field is irrigated, each zone is watered for a specific length of time, known as the irrigation set length. Often, a grower irrigates each zone for a certain set length and then immediately begins the cycle again. The reasons for watering each zone for multiple sets are discussed below in the section on irrigation set length.

Soil moisture monitoring

When switching to drip irrigation from furrow or sprinkler irrigation, there is an initial learning curve associated with deciding when to irrigate. Soil moisture sensors make this decision easier. In central Oregon, Watermark Soil Moisture Sensors have been used.

Install sensors in groups of three at a depth of 8 inches in the carrot row. An 8-inch depth eliminates wide fluctuations in sensor readings based on time

Caroline E. Weber, student research assistant, Jefferson County; Marvin D. Butler, Extension crop agent, Jefferson County; Claudia K. Campbell, research assistant, Jefferson County (all of Oregon State University); Brad A. Holliday, Central Oregon Seeds, Inc., Madras, OR; Jim Klauzer, Clearwater Supply, Ontario, OR.

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of day, which occur if sensors are installed closer to the surface. Also, at depths of less than 8 inches, sensors do not accurately reflect the moisture available to the carrot's root zone, and they often dry more quickly. Depths greater than 8 inches measure deep soil moisture. While deep moisture is important, irrigation scheduling is not normally based on moisture at these levels.

Place 6 to 12 sensors (in groups of 3) in each field. This provides a more accurate average than would three sensors. Having six to nine sensors in a field is helpful if sensor difficulties are encountered. Twelve sensors often are used in fields with many zones, as six can be placed in both the first and last zone watered.

Wiring sensors to a datalogger provides convenient access to soil moisture readings. In central Oregon, the AM400 (generally referred to as a Hansen) has been used. In addition to showing soil moisture levels, the Hansen also provides a soil moisture graph and displays the current soil temperature. The data can be downloaded onto a computer. The number of sensors that can be wired to a datalogger varies with type; a Hansen can hold six.

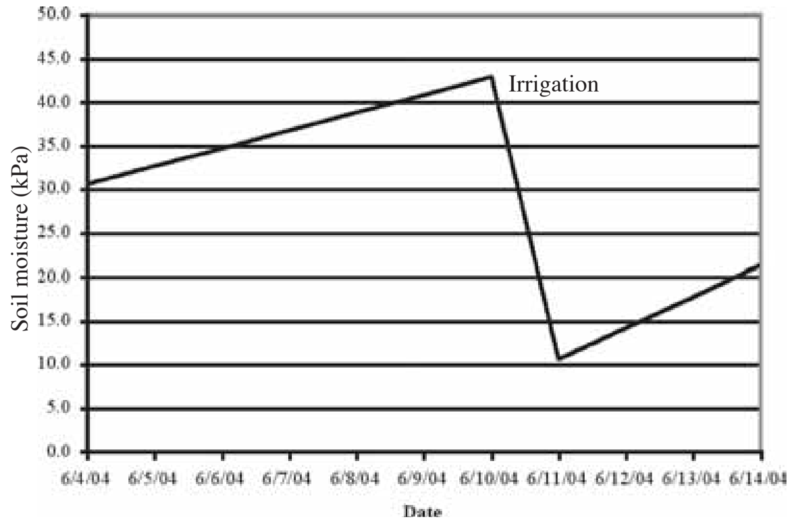
Alternatively, sensor readings can be obtained with a hand-held meter, such as the Watermark Digital Meter, which reads many types of Watermark sensors.

Sensor readings range from 0 kPa to 199 kPa, with 0 kPa indicating full soil saturation, and 199 kPa indicating extremely dry soil.

When to water

Based on the 2-year study at the Central Oregon Agricultural Research Center, it is recommended that irrigation begin when the average sensor reading is 40 kPa. (A Kilopascal, or kPa, is a measurement of soil moisture. When the soil is nearly saturated, the reading is 15 kPa. As the number gets higher, the soil is getting drier.) Watering at 40 kPa was shown to maximize carrot seed yield. It is believed that this level is optimal because it provides some moisture stress without allowing the carrots to get too dry. Stress triggers more prolific seed production. Additionally, this moisture level prevents excessive wetting of the root, which can cause lodging and various types of root rot such as *Alternaria radicina*.

Irrigation frequency depends on soil type, weather conditions, and plant growth stage. As shown in Figure 1, fields often lose moisture at a faster rate in July when carrots are pollinating, thus requiring more frequent irrigation.



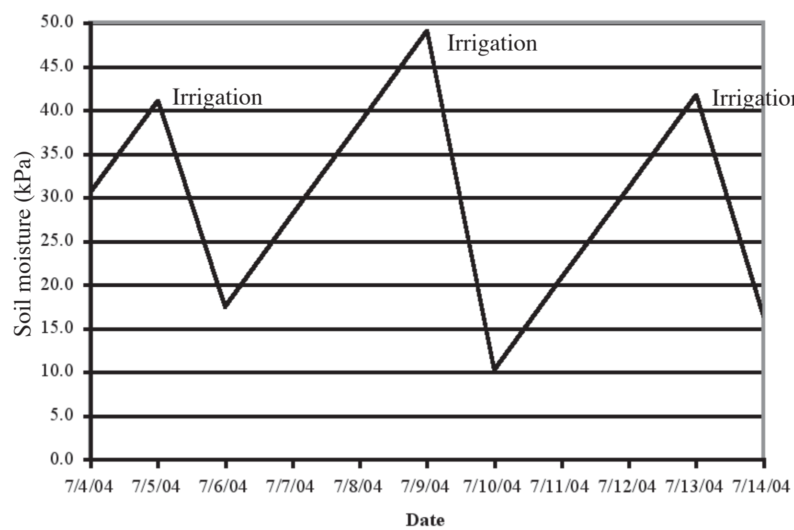


Figure 1.—Comparison of soil moisture levels in June and July. (Top graph indicates soil moisture levels for a 10-day period in June; bottom graph indicates soil moisture levels for a 10-day period in July.)

The normal range for irrigation frequency is every 3 to 7 days.

Often, drip-irrigated fields dry faster than comparable sprinkler- or furrow-irrigated fields. In addition to applying less water, drip irrigation leaves part of the ground unwatered, and this dry soil wicks water away from the root zone.

Length of irrigation sets

The length of time to irrigate each zone depends on a variety of factors. Selecting effective set lengths is an important part of maintaining irrigation effectiveness and efficiency throughout the season.

The first irrigation of the season establishes the wetting pattern and is often 24 to 36 hours long. The fine silts in the soil are moved laterally with the initial wetting front, and they become fixed when the water ceases to move outward. Expanding a wetting pattern beyond this boundary requires an excessive amount of water. Consequently, the season's first irrigation is the most important.

Subsequent irrigation sets should maintain the initial wetting pattern. If the proper irrigation set length is selected, maintaining the wetting pattern is relatively easy.

As seen in Table 1, drip irrigation sets for seed carrots normally range from 8 to 12 hours. Effective set lengths promote horizontal water movement rather than gravitational (downward) pull. As the water is applied, it creates a ball around each emitter, and the ball expands toward the carrot row.

Multiple, relatively short sets create small balls of water, which lack significant gravitational pull. As each new set is applied, it pulses the previous set toward the row, thus promoting horizontal movement. In many cases, growers can apply less cumulative water because the water reaches the carrot row sooner.

However, if sets are too short, they can be less effective. It is thought that too much drying occurs between sets. Based on growers' experiences with short sets in central Oregon, 4-hour sets present this problem.

Long sets of 24 hours or more create increasingly large balls of water with greater gravitational pull. These long sets are inefficient, as water is moved downward rather than toward the carrot root zone. If the water is unable to move downward, it moves to the surface, creating excessive puddling.

Eight- and 12-hour irrigation sets have been the most effective in the Madras and Culver areas of central Oregon. Two consecutive 8-hour sets are consistent with the short, pulsing sets discussed

Table 1.—Selecting the proper irrigation set length.

Set length	Water applied per set[1]	Number of sets applied[2]	Selection criteria[3]
4 hours	0.34"	6–8	Not used due to the large number of sets that must be applied.
8 hours	0.68"	2	When one 12-hour set cannot push the water to the carrot row or when 12-hour sets cause excessive puddling. Automatic switching valves are preferred when using 8-hour sets.
12 hours	1.02"	1–2	When one 12-hour set saturates the row without excessive puddling and automated switching valves are not used.
24 hours	2.03"	1	Not used due to tendency to overapply water and oversaturate the soil.

[1]These calculations assume 30-inch centers and 0.22-gal/min/100 ft tape, which are common in central Oregon.

[2]Based on the number of sets normally required to saturate the soil in the row and cause sensor readings to fall to 10 to 20 kPa.

[3]Based on experience in central Oregon; may not be true for other regions.

above. They cause more horizontal movement than a single 16-hour set. Two 12-hour sets have the same effect and are more efficient than a single 24-hour set. In some cases, a single 12-hour set is sufficient because it pushes the water all the way to the carrot row.

Several things should be considered when choosing between 8- and 12-hour sets. If automated switching valves are not used to change water between zones, 12-hour sets are the norm. This set length allows growers to manually change zones at convenient times of day.

Eight-hour sets are preferred if one 12-hour set does not reach the carrot row and the grower has automated switching valves. Eight-hour sets also can be valuable if 12-hour sets cause excessive puddling.

After irrigating, sensor readings should fall to the range of 10 kPa to 20 kPa. It is not necessary for sensors to read 0 kPa. Keep in mind that it can take as long as 24 hours after the last irrigation set has been applied for sensors to fully reflect the change in soil moisture.

Figure 2.—Your soil moisture sensors are important tools that help you decide when to irrigate. Make sure they are installed properly.

Soil moisture sensor issues

Soil moisture sensors generally work correctly and provide useful information (Figure 2). However, certain problems can decrease the usefulness of sensor readings. Occasionally, the installation is faulty, the sensor fails, or the sensor is not located in an area representative of the average field conditions.

If installation is faulty, a hole can let water into the area around the sensor, causing it to read wet continually. Alternatively, a sensor can lose contact with the soil or be excessively compacted into the soil, both of which cause the sensor to quit absorbing soil moisture.

Most sensor difficulties occur when water does not reach the carrot row, where sensors are placed. Sometimes, sensors are placed in an unrepresentative area of the field where the water subs incorrectly, preventing the water from reaching the carrot row and the sensor. Difficulties also can occur if the irrigation set length is incorrect (see the previous section).

Additionally, water may not reach the row if growers do not irrigate at 40 kPa. If fields dry to sensor levels in the range of 65 kPa to 90 kPa or drier, the wetting pattern set at the beginning of the year is partially destroyed. In addition, it takes significantly more water to resaturate the soil than if irrigation begins at 40 kPa.

Growers can remedy the issues discussed above during the season. Unfortunately, two additional problems that prevent water from reaching the row cannot be solved until the next season.

One problem occurs when the tape is ineffective in a particular soil type. In the 2003 season, some central Oregon growers used a tape that emitted 0.15-gal/min/100 ft rather than the 0.22 gal/min/100 ft tape normally used in this region. The smaller emitter flow rate was unable to push the water to the row and was ineffective in several local soil types when compared with the higher flow tape.

Planting carrots on 24-inch centers introduces another variable that can affect sensors. In this planting arrangement, the tape is placed 12 inches from the row, rather than the standard 3 to

5 inches. A 12-inch distance is not necessarily problematic, but keep in mind that water has more difficulty reaching the carrot row. Consequently, it is harder to maintain moist sensor readings for an entire season.

Filter station management

Proper management of the filter station is necessary to protect system health and allow accurate irrigation application. Normally, each station has two or more sand media filters (Figure 3). The sand media filters provide filtration to 200 mesh, which is necessary to clean the water so that it flows unrestricted through the tape emitters.

Sand media filters are designed to be self-cleaning. During a process called backflushing, one filter reverses the water flow direction with water supplied from the other filter(s). The water is expelled from the system, along with undesirable silts and organic materials.

It is recommended that sand media filters have a pressure differential of 7 psi or less between the inbound pressure and the delivery or downstream pressure. When the pressure differential exceeds 7 psi, the flow to the field is substantially reduced.

Calculate the pressure difference by subtracting the downstream pressure from the upstream pressure. If the pressure differential exceeds 7 psi, backflushing the system can solve the problem.

The backflush controller sets the conditions of the four-phase backflush to maintain the health of the filters. The controller manages the interval between flushes (often called periodic), the duration of the flush, and the time delay (dwell) during the flushing sequence of multiple filters.

The periodic interval is determined by how long it takes to build up a 7-psi pressure differential, as discussed above. This generally depends on the quality of the water, which can change throughout the growing season.

The dwell is the time between the flushing of each filter, normally about 30 seconds. This delay allows the water flows to normalize before the next filter flushes.

The backflush gate valve controls the amount of flushing that occurs. If the valve is closed too far, silt will not be adequately flushed from the filters and the filter will become plugged. If the valve is open too far, sand washes out of the filters, reducing the available filtration medium. To select the correct backflush valve setting, sample the water near the end of the backflush sequence, when the water looks clear. In a clear, normal-sized cup, there should be 5 to 10 grains of sand in the bottom.

The pressure-sustaining/pressure-reducing valve maintains adequate pressure in the filters for cleaning, while reducing the mainline pressure to manageable levels for field delivery of the irrigation water. The valve must be adjusted correctly. To adjust the valve, first set the pressure-sustaining pilot (upstream) to maintain at least 30 psi during the backflush. Then, adjust the pressure-reducing pilot (downstream) to the maximum pressure required in the layflat mainline.

The flow meter is the overall system health indicator. The drip irrigation system supplier should

Figure 3.—Typical filter station, using two sand media filters, in central Oregon.

provide an estimate of the flow in each zone. The flow normally is within 5 percent of this value.

Note the flow during the initial irrigation, as this will be the standard flow for the season. Increased flow later in the season indicates that substantial leaks have occurred and repairs are needed. If the flow progressively declines during the season, the tape may be plugged. The next section suggests how to prevent and correct leaks and plugging.

System maintenance

Monitor the drip tape for physical damage throughout the season. Holes can be caused by animals such as rodents, deer, and wireworms. Hoeing crews also can damage the tape.

Repair holes as soon as possible according to the recommendations of the drip irrigation system supplier. Holes in the tape cause the row to be irrigated incorrectly.

To reduce tape damage caused by hoeing, turn on the water before the crew begins. With the water running, the crew can see the tape and avoid it. If they do make a hole, it will be immediately apparent and can be repaired right away.

Plugged tape is very damaging to the crop. It is easier to maintain system hygiene than to fix a plugging problem once it is apparent.

One cause of plugging is biological activity in the emitter track. Application of chlorine through the drip tape at regular intervals will minimize biological activity. Chlorine normally is applied during July or August. Consult the system supplier and carrot crop field consultant for product strength, rate, and application frequency.

Another problem is sediment accumulation. Flushing the tape lines once every 30 days can prevent this problem. To flush tape lines, open them during a regular irrigation. Normally, about 10 tape lines are opened at one time. Limiting the number of open tape lines keeps the water velocity high, which improves the cleaning action.

If tape lines are not effectively maintained and plugging occurs, the first step is to determine the source of the plugging. Fertilizer, particularly phosphorus products, can be a potential source of flow restriction. Biological activity in the form of algae also can plug the tape, although, as noted above, regular use of chlorine is highly effective in preventing this source of plugging.

After the plugging source has been determined, the next step is choosing the appropriate product to aid in system recovery. The proper selection of a cleaning product depends on the contaminant source. Contact a drip irrigation system supplier for product selection guidance.

Chemical application

Drip irrigation systems can be used as a distribution system for fertilizers and pesticides. Due to the uniformity of water delivery, the products are safely and effectively delivered to the crop. Since the materials are delivered directly to the root system for immediate use, smaller amounts can be used.

Products are introduced into the irrigation system using a suitable injection pump. The pump delivers accurate, calibrated rates and consistency of products to the crop. Additionally, injection pumps have a backflow protection device. Such a device is necessary to prevent the possibility of any product entering the water supply. Other safety equipment may be required; contact a drip irrigation system supplier for details.

Fertilizer is commonly introduced into the irrigation system in front of the filter station so the filters can remove any precipitates that occur in the solution. Fertilizer normally is applied at half the normal rate because it is spoon-fed directly to the root system.

Systemic insecticides and nematicides sometimes are used in drip systems for enhanced insect and nematode control. Normally, the product is introduced in the middle of the set, allowing a clean water period to push the product out of the drip tape and closer to the crop.

In some instances, the effectiveness of insecticides is enhanced by the addition of a pH-buffering agent that alters the pH of the irrigation water to 5. However, a second injection pump is needed in order to add a pH-buffering agent.

Currently, no herbicides are labeled for use with drip systems. In field experiments, it has been found that rates must be reduced substantially to prevent crop injury. Further work is being done in this area, and growers would be well advised not to attempt herbicide application through a drip system on a commercial scale at this time.

For more information

Contact your county office of the OSU Extension Service for additional information on drip irrigation.

OSU publications

The following publications are available from central Oregon county offices of the OSU Extension Service. Check the county government section of your telephone book. These publications are also available on the Web at **oregonstate.edu/dept/coarc**

Enterprise Budget: Carrot Seed Production Under Drip Irrigation. 2004. OSU Extension publication EM 8849. 6 pp.

"Drip Irrigation on Commercial Seed Carrots and Onions in Central Oregon." 2003. *Central Oregon Agricultural Research Center Annual Report,* SR 1053. pp. 139–142.

"Drip Irrigation on Commercial Seed Carrots and Onions in Central Oregon." 2002. *Central Oregon Agricultural Research Center Annual Report,* SR 1046. pp. 166–169.

"Drip Irrigation of Seed Carrots in Central Oregon: Effect of Irrigation Threshold on Yield." 2001. *Central Oregon Agricultural Research Center Annual Report,* SR 1039. pp. 111–114.

"Drip Irrigation of Seed Carrots in Central Oregon: Preliminary Data on the Effect of Irrigation Threshold on Seed Yield." 2000. *Central Oregon Agricultural Research Center Annual Report,* SR 1025. p. 194.

Nutrient Management Guide: Hybrid Carrot Seed (Central Oregon). 2004. OSU Extension publication EM 8879. 6 pp.

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