The Advantages of Closely Spaced Emitters

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Abstract. *There are many advantages in using drip irrigation with closely spaced emitters. In fruit and vegetable row crop production, many producers are successfully using drip tape systems to germinate seed and set transplants without the traditional use of sprinklers. A technique common to their success is the use of drip tape with closely spaced emitters to achieve desired wetting patterns, and the specific techniques of three producers growing strawberries and celery in California and onions in Oregon are studied. Benefits include reduced runoff and decreased water, labor, equipment and energy costs associated with sprinkler irrigation. Additional benefits include reduced weed germination, improved field accessibility, reduced incidence of disease, improved planting bed tilth, improved food safety and improved farm safety. In addition, a field trial conducted by Clearwater Supply in Ontario, OR showed that drip tape with emitters spaced 8 inches apart created superior wetting patterns than drip tape with emitters spaced 12 inches apart. Finally, a review of a recent report from Cal Poly San Luis Obispo's Irrigation and Training Research Center (ITRC) reveals that closely spaced emitters can improve salinity management, can provide a better wetted pattern, can increase crop quality, and can reduced both purchase and operational costs versus wider spaced emitters.*

Keywords. Irrigation, drip, drip irrigation, subsurface drip irrigation, SDI, drip tape, tape spacing, emitter spacing, wetting pattern, sprinkler irrigation, runoff, labor, energy, seed germination, transplant setting, strawberry, celery, lettuce, onion, artichoke, organic, weed germination, disease, farm safety, food safety, salinity.

Introduction

Many fruit and vegetable row crop growers use drip tape with closely spaced emitters as their primary irrigation method in their growing system, but also use a secondary sprinkler system to germinate the seed or "set" the transplants at the beginning of the season. This secondary sprinkler system often wastes water where conditions are hilly or windy, and where plastic mulch is present, because irrigation water runs off and is not beneficially used. In some cases, this runoff water contaminates other water resources or erodes soil. Further, the use of a secondary sprinkler system requires additional expense for the sprinkler equipment itself, for the labor to move the pipe, and for the energy to achieve higher pumping pressures. For these reasons, innovative growers have developed ways to use the existing drip irrigation system to supply adequate germination and transplant moisture, and have found that the use of closely spaced emitters contributes to their success. The obvious benefits are reduced costs and improved usage of existing resources, but other benefits have been reported as well.

Growers cite significant cultural advantages to eliminating sprinkler use. First, weed germination is reduced since drip targets irrigation water to the planting bed while sprinklers wet the entire field, including furrows, field edges and roads. Thus, unwanted weeds are germinated with sprinklers that require cultivation, hand weeding and/or herbicide treatment. This is especially important in organic fields where expensive hand labor must be used to weed

since herbicide use is prohibited. Second, the incidence of disease is reduced since the plant canopy remains dry and the air less humid. This has significantly reduced fungicide sprays and/or crop loss, and again is especially important in organic fields where fungicide use is prohibited. Third, field accessibility is improved since sprinkler pipe does not impede other cultural operations. Fourth, the planting bed remains soft and is not hardened or crusted over from the use of sprinklers. Fifth, food safety may be enhanced since less standing water is available to harbor E.Coli. And sixth, farm safety conditions may be improved since heavy sprinkler pipe is no longer moved by laborers through uneven terrain that is often steep and/or muddy.

The following discussion examines actual case studies of three growers who have successfully germinated seed and set transplants with closely spaced emitters. Their techniques are presented, along with the varied benefits. In addition, field studies conducted by Clearwater Supply in Ontario, Oregon are reviewed which compare the wetting patterns of two different emitter spacings, 8 inch versus 12 inch. Finally, excerpts from Cal Poly San Luis Obispo's "Drip and Micro Irrigation Design and Management" manual published in 2007 by the Irrigation Training and Research Center (ITRC) are provided in support of the use of closely spaced emitters to improve salinity management, to create better wetting patterns, to increase crop quality, and to reduce both purchase and operational costs versus wider spaced emitters.

Case Study 1: Reiter Berry Farms, Watsonville, CA

Frank Estrada, area manager for Reiter Berry Farms in Watsonville, California manages over 300 acres of strawberries for Driscoll and sets strawberry transplants with drip irrigation. "We stopped using sprinklers over three years ago for anything except pre-irrigation prior to bed prep," says Reiter. He reports that soil prep, tape placement and irrigation scheduling are the keys to success, and that beds must be square and consistent with 27-29 inch wide tops. For strawberries on 52 inch centers, two rows of premium drip tape with closely spaced outlets and a high flow rate are placed in the center of a dry bed, 10 inches apart, and buried 0.5 – 1.0 inch deep. The beds are then irrigated about 3-4 hours and marked. Then, transplants are placed 5 inches from each tape line on the bed shoulder and packed in by laborers, and then machine rolled. The block is then immediately irrigated until water from the drip lines begins to bleed from the beds. In a clay loam, this occurs after about 8 hours of irrigation. In a sandy loam, this occurs sooner, and may require more frequent irrigation for shorter duration.

"There is no difference in quality or production in my 'drip only' fields versus sprinkler fields," says Estrada. "We save in sprinkler equipment and labor costs, and use less water and energy

Total bed width is 27-29 inches wide.

Tape is placed 10 inches apart, about 0.5 – 1.0 inches deep.

Strawberry transplants will be placed 5 inches from each of the tape lines.

during the first two weeks of production. Since drip runs at lower pressures and wastes less water than sprinklers, using drip for the rest of the season saves water and energy over sprinklers as well." Another reason Estrada prefers drip to sprinklers is the reduced incidence of weeds in his organic fields. "With drip, I'm not applying water in-between the beds, so weed growth is greatly reduced. With sprinklers, weeds germinate everywhere and I am forced to hand weed, which is expensive."

Case Study 2: Naumann Ranch, Oxnard, CA

Mike Naumann of Naumann Ranch in Oxnard, California manages 800 acres of mixed vegetables along with his brother Brian. "We haven't used flood or sprinklers for years," says Naumann. This was accomplished by developing a simple valve and layflat system that allows immediate irrigation of new celery transplants. "After each pass of the transplant machine, we open up additional drip lines with closely spaced emitters from the layflat by changing positions of an improvised marine valve – this way, newly transplanted rows receive water *immediately* after planting," says Naumann. "This is in contrast to waiting for an entire block to be completed. The result is reduced mortality and stronger plant growth. Not only have we increased yields and uniformity, but we have eliminated the expense of bringing in traditional sprinklers to set transplants, and the unwanted side effect of runoff."

A valve opens up additional drip lines after each pass of the transplant machine.

Rollers help to properly secure the transplants in the soil such that the entire bed is quickly 'blackened' with moisture soon after the drip lines are pressurized. "If we were using sprinklers, the plants would have to wait until the block is completely planted, and would likely stress before receiving water. The logistics of above ground pipelines would be difficult to work around as well, and windy conditions often ruin sprinkler uniformity and drift water into unwanted fields or roadways. We have cut water use in half compared to other irrigation methods used in the past, and have also saved on irrigation labor which reduces our costs." In the same geographic region, artichoke transplants are set with drip tape as well.

Rollers help secure the transplants in the bed.

Food safety is one of the more difficult challenges vegetable growers face. "Given the current pressures regarding food safety, we don't feel we could even farm if it weren't for drip," continues Naumann. The Naumanns believe their drip irrigation and harvest practices help safeguard them from the potential disasters that other growers have experienced in recent months and years. "E. Coli grows where there is water. In drip irrigated fields, less area is irrigated, and it is likely that less water runs off or is left standing," says Michael Cahn, University of California Farm Adviser in Monterey County, CA. Thus, avoiding sprinkler usage may contribute to food safety as well.

Celery is transplanted into dry soil.

Drip tape with closely spaced emitters quickly blackens the bed with moisture immediately after transplanting.

Case Study 3: Standage Farms, Inc., Vale, OR

Larry Standage of Standage Farms, Inc. in Vale, Oregon germinates onion seeds with his drip irrigation system. The drip tape is installed after the onion seeds are planted, the tape supplying the moisture for germination. Drip tape outlets are spaced 12 inches apart, and the tape flow rate of .22 gpm/100' translates into an application rate of .06 inches per hour. Standage feels that the best wetting pattern is achieved with a 12 hour set, with intervals between irrigations determined by weather and sensors.

"Drip nurtures a healthier, stronger plant, which really shows up during extreme heat events," explains Standage. "Drip also creates an advantage for cultural activities

Germinating onion seed with closely spaced emitters helps ensure uniform production in size, shape and color.

during the growing season since the furrows are always dry as opposed to flood, which always leaves wet spots. The root system is more robust which prevents stress, and uniformity of water application translates into uniformity of crop. This is a huge advantage for our customers, and even in our own packing sheds, because variable size, shape and color creates problems in both packing and marketing. The contents of each 50 pound bag of onions is superior because the crop is more uniform in size, shape and color, thus the customer is more pleased. I use drip to keep my customers coming back."

Other growers are successfully germinating lettuce seed using similar bed shaping, tape placement and irrigation scheduling techniques. After germination, the lettuce seedlings are thinned to a final spacing by hand with a hoe. The benefits include keeping the furrows dry to avoid weed germination, and reducing disease pressures. These two benefits are especially important in organic production where treatment is very expensive without chemicals. Improved bed softness is also cited as a benefit of drip versus sprinklers.

Lettuce seeds are germinated with closely spaced emitters.

Seedlings are then thinned with a hoe.

Field Trial by Clearwater Supply

A field trial conducted by Jim Klauzer of Clearwater Supply in Othello, Oregon provides visual evidence of the advantages of closely spaced emitters to achieve desirable wetting patterns. The top photo below shows a 12 inch emitter spacing on the left, and an 8 inch spacing on the right. Both tapes emit the same amount of water: .22 gpm/100'. The soil is an Elijah – Sebree silt loam, one of the more difficult soils in the Treasure Valley. Clearly, the 8 inch spacing is creating a wetting corridor more quickly than the 12 inch spacing, a big plus for growers who seek to germinate seed and set transplants with drip. The photo on the bottom shows the 8 inch spacing after 30 hours of irrigation, where nearly the entire planting bed has been moistened. This type of wetting pattern is essential to germinate seed or set transplants without the use of sprinklers.

Above: Toro Aqua-Traxx drip tape, 12 inch spacing, .22 gpm/100' on left; 8 inch spacing, .22 gpm/100' on right.

Below: Toro Aqua-Traxx drip tape, 8 inch spacing, 0.22 gpm/100' after 30 hours of irrigation.

ITRC Excerpts Regarding Emitter Spacing

Choosing the right drip tape emitter spacing can be more of an art than a science. This is because of the many variables that exist in each farming application, including tape placement, soil type, crop, plant population, soil and water salinity, tape quality and cost, etc. Fortunately, Cal Poly San Luis Obispo's recent Drip and Micro Irrigation Design and Management Manual, published by the Irrigation Training and Research Center (ITRC) in 2007, provides a great deal of guidance for this important decision. In particular, the new manual discusses how closely spaced drip tape emitters can enhance salt management for seed germination, leach salts in permanent crops, and dilute soil salinity for salt sensitive crops. In addition, the manual highlights some of the agronomic and economic disadvantages of using widely spaced emitters. The following provides some discussion and excerpts from the manual.

Closer Emitters Improve Salinity Management

Salinity management is especially important during seed germination and emergence, and closely spaced emitters and bed shape can help. "Use surface tape (or tape only a few centimeters below the soil's surface) with closely spaced emitters to leach salts downward. In more arid areas, widely spaced holes (i.e. one tape for every two rows, or hole spacing greater than 16") can cause salt buildup between the holes. If seeds are later planted in those salty areas, they will not emerge. Decades of experience with flood irrigation has taught farmers to shape furrows so that salt-laden irrigation water evaporates at high points in the bed – and the plants/seeds are located at lower points. Likewise, drip irrigated beds should be shaped with an indentation where salts will accumulate away from the seed line planted below the indentation." (pgs.76-77).

Salinity management is also important in established drip irrigated orchards and vineyards. Drip laterals typically wet less than 40% of the total soil surface, and over time, salts carried to this wetted strip through the irrigation water will safely leach away from the soil close to the emitter. However, salts will concentrate in the soil as distance from the emitter increases. For this reason, the standard "leaching requirement" equations and principles for maintenance leaching are not applicable for drip/micro irrigation. Instead, periodic "reclamation" leaching is needed to remove the salt from these outer zones of the soil.

Low-flow drip tapes, spaced 0.30 m apart, used to apply the leaching water. From ITRC page 82.

For reclamation, broadcast flood or sprinkler irrigation is typically used to leach these concentrated salts below the root zone, but this can be wasteful since only 20-40% of the surface area of the orchard or vineyard needs to be leached. "If 100% of the soil area is wet to treat this 20-40% of the area, 2.5 to 5.0 times the necessary leaching water will be

applied. Most of the water is ineffective because it is applied to zones that do not need leaching." Instead, ITRC researchers have suggested using a portable drip tape system to "target leach" the orchard or vineyard dripline zone. In 2005, Burt and Isbell showed that salts were effectively removed in a pistachio orchard using six lines of retrievable surface drip tape with emitters spaced closely, 12 inches apart, to "target leach" the dripline zone. Subsequent leaching experiments closely match the pistachio orchard results. Once leaching is complete, the drip tape can be retrieved and reused. In this way, closely spaced tape emitters perform leaching with less water (pgs. 82-83).

Drip irrigation can also help dilute soil salinity such that yields may be improved. Yields typically decrease once the soil salinity reaches a threshold value, and as the soil dries in-between traditional irrigations, salinity concentration becomes worse. Irrigating frequently with closely spaced emitters can help. "Years of experience with drip have shown that if it is managed so that the soil salinity remains dilute, yields can be higher than they would be with the same water quality using sprinklers or furrow irrigation. For some crops such as processing tomatoes, some research has observed (Hanson and May, 2003) that on very salty fields the crops have no damage even though the salinity levels would traditionally cause serious yield declines." (pg. 86).

Closer Emitters Provide a Better Wetting Pattern for Better Results

Closely spaced emitters can also help achieve the right wetting pattern, increase crop quality and reduce both purchase and operational costs vs. wider spaced emitters. "For the Central Coast of California, most growers use an emitter spacing of 8 inches – 16 inches, with a shallow burial depth. Even with these close spacings it may be important to match the spacing to the soil type. Closer hole spacings can result in a more continuous soil wetting pattern. The most common hole spacing in California is 12 inches. Eighteen inch spacing is often too great. In order to use wide spacing (in SDI applications), one must do all of the following: a) Raise the pressure to 20 psi during germination to provide a higher flow rate that subs better, b) Apply water to the soil surface until it is very wet (in fact, water will actually be standing in the furrows), and c) Use heavy wall drip tape (about 15 mil) in order to handle the high pressure without tape damage." (pg. 288.)

Clearly, buying heavier mil tape, increasing pressures and wetting the soil surface are all undesirable side effects of using widely spaced emitters in an SDI application. Initial buying costs and post-purchase operation costs will be higher, and soil surface wetting may damage crop quality and/or encourage unwanted weed growth. For optimal performance, closely spaced emitters are often the best choice.

In summary, ITRC's new manual points out that properly managed drip systems with closely spaced emitters have many advantages. First, closely spaced emitters can help push salts away from seeds and enhance germination. Second, closely spaced emitters can be used to perform reclamation leaching in orchards and vineyards and significantly reduce water requirements for this task. Third, closely spaced emitters help to dilute soil salinity such that crop yield is not adversely affected. And fourth, closely spaced emitters can be used to manipulate the wetting pattern as desired without raising pressures or requiring thicker mil tapes.

Drip tape with closely spaced emitters is used to set celery transplants along California's Central Coast.

Conclusion

In conclusion, the fruit and vegetable row crop producers profiled are successfully germinating seed and setting transplants with closely spaced emitters instead of using sprinkler systems for this specific task. The use of closely spaced emitters helps to achieve the desired wetting pattern, which is essential to germination and transplant setting success. In addition, growers pay special attention to soil preparation, drip tape placement and irrigation scheduling. In addition, they have developed special techniques to immediately apply moisture to rows of transplants immediately after the transplant machine completes each pass.

The obvious benefits of using closely spaced emitters to eliminate the use of sprinklers for germination and transplants are numerous. First, the costs associated with the use of sprinklers is obviously reduced. Second, runoff and water use is reduced, and existing resource use is improved. Third, weed germination is reduced since drip targets irrigation water to the planting bed while sprinklers wet the entire field, including furrows, field edges and roads. Fourth, the incidence of disease is reduced since the plant canopy remains dry and the air less humid. Fifth, field accessibility is improved since sprinkler pipe does not impede other cultural operations. Sixth, the planting bed remains soft and is not hardened or crusted over from the use of sprinklers. Seventh, food safety may be enhanced since less standing water is available to harbor E.Coli. And eighth, farm safety conditions may be improved since heavy sprinkler pipe is no longer moved by laborers through uneven terrain that is often steep and/or muddy.

In a field trial conducted by a dealer in Oregon, the use of drip tape with emitters spaced 8 inches apart created superior wetting patterns versus drip tape with emitters spaced 12 inches apart. Finally, a review of a recent report from Cal Poly San Luis Obispo's Irrigation and Training Research Center (ITRC) reveals that closely spaced emitters can improve salinity management, can provide a better wetted pattern, can increase crop quality, and can reduced both purchase and operational costs versus wider spaced emitters.

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