**Drip germination of lettuce: strategies for enhancing lateral movement of moisture around buried drip tape**

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Many growers are successfully using drip systems to irrigate lettuce from planting until harvest without the supplemental use of sprinklers. Full-season use of drip may reduce production costs by eliminating the need for sprinklers and minimize irrigation run-off that is often associated with overhead sprinklers.

Attaining uniform germination is a considerable challenge to using drip irrigation for an entire lettuce crop. Moisture from shallowly buried drip lines must consistently reach the seed at all locations within a field for a uniform stand to emerge. During the last two seasons we conducted replicated and non-replicated field trials to evaluate strategies for improving the lateral movement of moisture from the drip tape to the seedline. Trials focused on bed preparation and tape characteristics, such as emitter spacing, depth, and emitter discharge rate (high flow, medium flow). We also evaluated chemical polymers for enhancing lateral movement of moisture. The following is a summary of results and recommendations based on these trials.

*Soil texture and bulk density*

We were most successful at germinating lettuce with drip on soils ranging from sandy loam to clay loam textures. The bulk density of the beds on these soils ranged from 0.97 to 1.13 g/cc. On a well-aggregated clay soil with a bulk density of 0.86 g/cc, moisture from the buried tape did not move adequately to the seedlines and sprinklers had to be used (Figure 1). Trials conducted on sandy loam soils on the east-side of the Salinas Valley appeared well suited for drip germination. Consistently, we obtained uniform emergence on these soils using between 2.5 to 3 inches of water.

*Bed preparation*

A replicated trial, comparing methods of bed preparation, demonstrated an improvement in germination if the beds were mulched to reduce the size of soil aggregates (Table 1). We also found that compacting bed tops using a weighted roller (a roller filled with water) after installing the drip tape increased germination (Table 1) and in another trial soil moisture in the seedline was greater using a weighted roller (Table 2). Rolling the bed tops may help with lateral movement of moisture by improving the contact between the drip tape and soil. Soil was often loosened by the shoe used to install the drip tape.

*Drip tape*

High distribution uniformity was one of the most important characteristics of the drip system which assured uniform germination in the commercial fields that we monitored.

Old tape with plugged emitters, or tape that was spliced with tapes of different flow rates may have contributed to poor emergence at one of our trials in a commercial field. Poor positioning of the tape between seedlines also reduced germination at other trials conducted in commercial fields.

*Tape depth*

Tape installed between 2 and 4 inches of depth satisfactorily moved moisture to the seedline and uniformly germinated lettuce on a range of soil types. A replicated trial that we conducted demonstrated that the spread of moisture on the bed surface and the soil moisture content in the seedline increased when the tape was buried at 2 inches rather than 3 inches (Table 3 ). However in practice, too shallow placement of tape was often problematic because the tape would end up on the bed surface at some locations or twist upside down or sideways. Because cultivation would not be possible in areas of the field where the tape was above ground, the shallowest depth that consistently places the tape below the depth of cultivation should be used. We found that the depth of tape in most fields varied by ± 1 inch.

*Emitter spacing and discharge rate*

Trials comparing 8 and 12-inch emitter spacing found no significant increase in soil moisture content within the seedline or an increase in germination rate (Table 3). In comparing tapes of different discharge rates (0.34 *vs* 0.5 gpm/100 ft), we found that beds with low flow tape had higher moisture content in the seedline using the same amount of water as high flow tape (Table 2) The low flow tape may allow additional time for the moisture to move across the bed to the seedline.

*Seed depth*

Seed depth was not compared in the replicated or non-replicated trials conducted in commercial fields. However, in most cases we chose to plant an 1/8 of an inch deeper than normal to assure that the seed was in contact with the soil. Since sprinklers were not used, we were not concerned that crusting of the soil surface would slow emergence. We often observed that seed that was not in close contact with soil did not germinate.

*Polymers for enhancing lateral movement*

Another strategy evaluated for promoting the horizontal movement of moisture from the drip tape was to add a chemical polymer to the irrigation water. Polyacrylamide (PAM) is used to reduce soil erosion by aggregating soil particles together. This chemical is a large, chained molecule that also increases the viscosity of water. In previous studies, we found that PAM, added to irrigation water, reduced infiltration into the soil at concentrations above 20 ppm; and may thereby force moisture to move laterally. However, results of our trials were mixed. On some soil types, where beds had settled and the bulk density was more than 1.1 g/cc, PAM enhanced the spread of moisture on the bed top and moisture content in the seedline (Table 4). In trials conducted on newly formed beds where soil bulk densities were less than 1.1 g/cc, PAM did not increase lateral movement of moisture (Table 5), and at concentrations above 50 ppm, PAM impeded the lateral movement of moisture. Possibly, the viscous nature of polyacrylamide reduced the ability of the soil pores to pull moisture horizontally.

*Irrigation schedule for germination with drip*

Although we did not compare different irrigation times or frequencies for drip germination, the procedure that we followed was to irrigate the longest on the first irrigation in order to allow moisture to reach the seedline. The first irrigation often required 1 to 3 inches of water depending on the soil type and factors discussed above. We observed that moisture moved very slowly on some fields. Rather than continue irrigating, we often stopped the irrigation to allow time for the moisture to redistribute in the bed during the night. In most cases moisture moved to the seedline by the next morning. After the initial irrigation, we applied less than 0.5 inches every other day until the seed germinated.

## Summary

Results from the numerous trials that we conducted in commercial and research fields suggests that the following factors were most important in achieving uniform germination with shallowly buried drip tape:

1. Soil textures ranging from sandy loam to clay loam were most suitable for drip germination.
2. Beds should be mulched to improve the uniformity of soil aggregates and reduce aggregate size and create more small pores to pull moisture towards the seedline.
3. The drip system should have a high distribution uniformity (> 85%)
4. Low flow tape (< 0.34 gpm/100ft) provided better lateral movement than high flow tape by allowing more time for moisture to be pulled by soil capillaries.
5. Drip tape should be accurately positioned between seedlines and installed between 2 and 4 inches of depth. Shallow placement is preferable as long as the tape is below the depth of cultivation.
6. After installing the drip tape, beds tops should be rolled with a weighted roller to assure that the drip tape is in contact with the soil.
7. Seed depth may need to be increased slightly to assure that it is in contact with the soil.

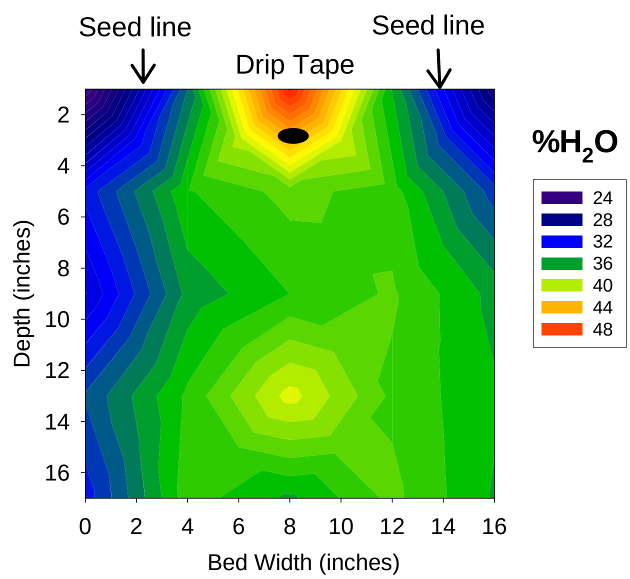


**Figure 1.** Moisture distribution around a drip line buried at a 3 inch depth on a Clear lake clay soil bedded to a bulk density of 0.86 g/cc.

Table 1. Effect of bed shaping and rolling of beds on soil moisture content, spread of moisture on bed top, and germination rate.

| Treatment | Gravimetric Soil Moisture | Wetted Width | Germination Count (4/23/07) | Germination Count (4/25/07) |
|---|---|---|---|---|
| | % | inches | ----------- plants/10 ft ----------- | |
| | --------------------------------- soil preparation -------------------------------- | | | |
| spike tooth bed shaper | 14.86 | 12.75 | 46.7 | 59.9 |
| mulching bed shaper | 14.78 | 12.88 | 52.7 | 63.7 |
| F-test | NS[x] | NS | 0.03 | 0.01 |
| | --------------------------------- bed compaction -------------------------------- | | | |
| unweighted roller | 14.67 | 12.68 | 48.3 | 61.5 |
| weighted roller[y] | 14.97 | 12.96 | 51.1 | 62.1 |
| F-test | NS | NS | 0.05 | NS |

x. treatment means are not statistically different

y. first pass with unweighted roller followed by a second pass with a weighted roller

Table 2. Effect of tape discharge rate, and rolling of beds on soil moisture content, spread of moisture on bed top, and germination rate.

| Treatment Description | Gravimetric Moisture[x] | Wetted Width[x] | Germination 11-Jun | Germination 13-Jun |
|---|---|---|---|---|
| | g/cc | inches | plants/10 ft | |
| ----------------------- Tape Discharge Rate -------------------- | | | | |
| 0.3 gpm/100 ft | 16.0 | 15.0 | 47.7 | 57.3 |
| 0.5 gpm/100 ft | 15.3 | 15.1 | 46.3 | 58.4 |
| F-test | 0.003 | NS[y] | NS | NS |
| ----------------------------- Rolling ------------------------------- | | | | |
| 1X | 15.4 | 14.7 | 46.5 | 56.2 |
| 2X[z] | 15.9 | 15.3 | 47.5 | 59.5 |
| F-test | 0.041 | 0.084 | NS | NS |

[x] 1st irrigation, 6/06/2006
[y] not statistically signficant
[z] 1st rolling was unweighted, 2nd rolling was weighted with water.

Table 3. Effect of drip tape depth and emitter spacing on soil moisture content, spread of moisture on bed top, and germination rate.

| Treatment Description | Gravimetric Moisture[x] | Wetted Width[x] | Germination 11-Jun | Germination 13-Jun |
|---|---|---|---|---|
| | g/cc | inches | plants/10 ft | |
| --------------------------------- Depth --------------------------------- | | | | |
| shallow (1.8 inches) | 16.3 | 15.7 | 49.4 | 58.2 |
| deep (3.1 inches) | 15.0 | 14.3 | 44.6 | 57.5 |
| F-test | 0.056 | 0.027 | NS[y] | NS |
| --------------------------------- Spacing ----------------------------- | | | | |
| 8 inches | 15.8 | 14.9 | 48.0 | 59.8 |
| 12 inches | 15.4 | 15.1 | 46.0 | 55.9 |
| F-test | 0.079 | NS | NS | NS |

[x] 1st irrigation, 6/06/2006
[y] not statistically signficant

**Table 4.** Effect of PAM concentration lateral movement of moisture on a Pico fine sandy loam soil. (tape discharge rate was 0.5 gal/min/100 ft and was buried at a 2 inch depth)

| PAM treatment | Wetted Width | | Gravimetric Moisture seed line | | shoulder | | average | |
|---|---|---|---|---|---|---|---|---|
| | inches | | ------- g $H_2O$/g soil ---- | | | | | |
| 0 ppm | 12.9 | a[x] | 17.8 | a | 15.5 | a | 16.7 | a |
| 50 ppm | 15.0 | b | 22.2 | b | 18.3 | a | 20.3 | b |

[x] means followed by different letters are statistically different

**Table 5.** Effect of tape discharge rate and PAM concentration on lettuce germination. Replicated trials 1 and 2 at Hartnell Research farm.

| PAM | Tape Discharge Rate (gal/min/100ft) 0.22 | 0.45 | 0.67 | Average |
|---|---|---|---|---|
| ( ppm ) | --------- germination (plants/10 ft) --------- | | | |
| 0 | 14.7 | 46.4 | 56.9 | 39.4 |
| 20 | 11.9 | 42.7 | 54.7 | 36.4 |
| 40 | 14.6 | 50.3 | 54.9 | 39.9 |
| 60 | 14.9 | 54.2 | 54.5 | 41.2 |
| | | | | |
| Average | 14.0 | 48.4 | 55.2 | |
| LSD.05 | NS | NS | NS | |