Project Title: Evaluation of single-use buried drip as a best management practice for irrigation and nutrient management of lettuce

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Abstract

The adoption of single-use buried drip tape has increased considerably in the Salinas Valley during the past few years. Potential advantages of drip compared to using sprinklers for establishment include eliminating the need and cost of overhead sprinklers, reduced labor costs for extraction of drip tape, improved uniformity of applied water and injected fertilizers, and more uniform germination. Despite these benefits, single-use buried drip for lettuce may not be fully optimized. Nitrogen applied to the soil surface as an anti-crustant or with a thinning machine may not be available to the crop but would need to be reported as applied N to the regional water quality control board. Additionally, over application of water during germination may cause leaching of residual soil nitrate. This project evaluated strategies to optimize water and nitrogen fertilizer using single-use subsurface drip for lettuce germination through field trials and monitoring of commercial fields.

Objectives:

The main objective is to document the water and nitrogen use of lettuce produced under single use buried drip in commercial fields and identify practices that can improve efficiencies. Specific objectives include:

Objective 1. Compare water and nitrogen use of lettuce under single-use, buried drip and overhead sprinklers followed by surface drip. **Deliverable:** Baseline data of water and nitrogen fertilizer use, nitrate leaching losses, and yield for lettuce produced with single-use subsurface drip and with sprinklers followed by surface drip.

Objective 2. Evaluate the effect of irrigation water volume on lettuce seedling emergence, weeds and nitrate leaching under buried drip. **Deliverable:** Understanding of the water requirement to optimize subsurface drip for germination of lettuce.

Objective 3. Evaluate low nitrogen containing thinning materials for killing lettuce and weeds with automated thinning machines. **Deliverable:** Identification of alternative, low N content products for removing unwanted lettuce plants using automated thinning equipment.

Objective 4. Extend results to the leafy green industry. **Deliverables:** 2 to 3 oral presentations at grower meetings, 1 newsletter/blog article

Procedures:

Objective 1. *Compare water and nitrogen use of lettuce under single-use buried drip and overhead sprinklers followed by surface drip*. Applied water, germination rate, soil nitrate, and weed emergence was compared among 7 iceberg and romaine lettuce fields, where a portion of the field was germinated by sprinklers and a portion using buried single-use drip tape (Fig. 1). Flowmeters were used to record water use during the germination and post establishment phases of the crop. Soil nitrate distribution in the soil profile before and after germination was evaluated to a depth of 3 feet. Weed emergence was evaluated before first cultivation of the crop.

Objective 2. *Evaluate applied water volume on lettuce seedling emergence and nitrate leaching under buried drip.* A small plot trial was conducted to assess applied water volume using buried drip on germination of an iceberg lettuce crop. The soil type of the field was a Cropley silty clay. The irrigation treatments were replicated 4 times in the field following a randomized complete block design and included the grower's standard practice as well one or two treatments with less water applied (medium applied water and low applied water). Individual plots measured 50 feet in length and 13.3 ft in width (4 beds). Mineral N (nitrate + ammonium) in the soil profile was evaluated before and after germination, as well as lettuce seedling emergence. After thinning all treatments were irrigated similarly. Biomass yield and final plant population was evaluated at crop maturity.

Objective 3. *Evaluate low nitrogen containing thinning materials for killing lettuce and weeds with automated thinning machines.* Evaluations of prospective low N containing thinning materials was evaluated for their efficacy in killing lettuce seedlings and weeds. Prospective materials were screened in small plot evaluations. Promising materials were evaluated with commercial applicators and compared with commonly used thinning materials.

Results

Comparison of water use, soil nitrogen, and weed control under single-use buried drip and overhead sprinklers

Table 1 summarizes lettuce type, bed width, number of seed lines, and dates of the drip and sprinkler germination trials. The range of applied water volumes applied among sites was considerable. On average 4.9 inches of water were applied during the first 10 days of the crop using sprinklers and 6.1 inches were applied for drip established lettuce (Fig. 1). The greatest volume of water applied for germination with sprinklers was 11.1 inches and the smallest volume applied was 2.5 inches. The greatest volume of water applied under drip was 10.8 inches and the smallest volume applied was 2.2 inches. Less than 3 inches of water was used for germination with drip at three sites of the seven sites. Less water used under drip than sprinklers to germinate lettuce at only 3 sites. Sites where the most water was used for drip germination had clay and clay loam textured soils (Fig. 1). These clay textured soils had well aggregated structure with large macropores that may interfere with wicking water laterally across the bed top to the seed line.

Other issues observed that may have reduced the efficiency of the drip systems to germinate lettuce were the placement of the tape in the bed and operational errors such as low pressure in the drip lines and disconnected drip lines and leaks. At some sites the length of the beds was more than 1000 feet resulting in low pressure and less water applied at the far end of the field. At other sites, the drip system was operated at pressures of less than 5 psi at the submain which resulted in very low pressures at the end of the drip line and consequently poor application uniformity. Pressure reducing valves were not used at any of the drip sites to maintain a consistent pressure during irrigations. Rather the irrigator controlled the pressure by adjusting the valve opener. Locations in the field where the tape was either buried too deep or was not placed in the center of the bed had less consistent wetting of the seed than in other areas of the field where the tape was correctly positioned. Hence, the entire field had to be irrigated extra time to assure that seed in these problematic areas germinated.

Germination rates were similar between the drip and sprinkler germinated fields (Fig. 2). Additionally, average nitrate distributed in the soil profile was similar between the drip and sprinkler fields, with the highest concentration near the surface and the lowest concentration at the 3 ft depth (Fig. 3) suggesting that nitrate leaching was not different between irrigation methods.

Weed populations were evaluated at 5 of the 7 sites, but only two sites had significant weed emergence (Fig. 4). At one site weed emergence was greater under sprinkler and at the other site weed emergence was greater under drip.

Evaluation of irrigation water volume on germination of lettuce and soil nitrate leaching under buried drip.

Applied water volumes for germinating the lettuce varied significantly among irrigation treatments (Table 2). The water volume applied in the low water treatment was about one third of the volume of water applied in the grower standard treatment during the first 10 days of the crop. Germination rates were not statistically significant between the medium water treatment and the grower standard but were statistically lower for the low water treatment compared to the grower standard (Table 3). However, final plant populations, biomass yield, and plant weight were not statistically significant among irrigation treatments (Table 4). Although soil nitrate was monitored before and after germination the laboratory analyses are not yet available at the time of this report.

Evaluation of low nitrogen containing thinning materials for killing lettuce and weeds with automated thinning machines.

Four trials were conducted to evaluate new materials for chemically thinning lettuce using automated thinning machines. Low N materials evaluated included potassium thiosulfate, calcium thiosulfate, potassium chloride, a proprietary product, and the herbicides *Rely* and *Raptor.* None of these products improved upon the conventional low N materials currently used such as the herbicide *Shark* for conventional systems and the herbicide *Suppress* for organic systems (data not presented). Most growers continue to use fertilizer nitrogen for chemically thinning lettuce but with the adoption of the Ag Order 4.0 in 2021 they will need to account for these applications as part of the total applied nitrogen in the A-R calculation.

Extend results to the leafy green industry. Results were communicated through a technical report, an article in American vegetable grower, and presentations at the fall and spring CLGRB meetings as well as the UCCE Irrigation and Nutrient Meeting held in February, 2021.

Conclusions and recommendations

The commercial field evaluations demonstrated that current practices may limit potential water savings of single-use buried drip for germination and establishment of lettuce. Although three sites were able to germinate crops with less than 3 inches of water, on average similar volumes of water were used for drip germination compared to sprinklers and germination rates and soil nitrate in the soil profile was similar between the two irrigation methods. The replicated trial demonstrated that often much less water is needed to germinate lettuce with drip. However, factors such as soil type, bed preparation, poor placement of the drip tape, or operational errors which impede the lateral movement of moisture to the seed line may result in extra water being applied to optimize germination of the entire block. The use of long drip lines (> 600 ft), lack of pressure regulation, and operating drip at low pressures also limits the application uniformity of single use drip tape and may result in irrigators applying extra water to moisten seed in problematic areas of the fields.

To attain the most successful outcome using single use drip, growers should determine which of their fields have soil textures that are most suitable for subsurface drip germination. In fields where drip germination is intended to be used, extra care should be taken to optimize bed preparation and drip tape placement to ensure that water moves efficiently laterally towards the seed lines. Finally, the operation of the drip system needs to be carefully monitored to confirm that the pressure of the tape is greater than 8 psi and the drip lines are connected throughout the irrigations.

Table 1. Summary of soil types and crop characteristics at trial sites.

Trial	Soil	lettuce type	bed width	number of seed lines	first irrigation drip	first irrigation sprinkler	harvest date	germination evaluation date
			inches	rows per bed				
1	Salinas clay loam	crisphead	40	2	4/29/2020	4/29/2020	7/9/2020	5/14/2020
2	Metz fine sandy loam	crisphead	80	5	5/1/2020	5/1/2020	7/8/2020	5/20/2020
3	Salinas clay loam	crisphead	80	5	5/23/2020	5/23/2020	7/24/2020	6/2/2020
4	Mocho silt loam	romaine	40	2	6/18/2020	6/19/2020	8/13/2020	6/29/2020
5	Metz complex	crisphead	80	5	7/11/2020	7/12/2020	9/14/2020	7/27/2020
6	Cropley silty clay	crisphead	40	2	8/16/2020	8/17/2020	10/27/2020	8/28/2020
7	Mocho silt loam	romaine	40	2	8/22/2020	8/22/2020	11/3/2020	8/28/2020

Table 2. Water volumes applied from germination to thinning in the replicated subsurface drip trial.

Treatment	Applied water#	
	inches	hours
Grower Standard	12.8	142
Low water	4.2	36
Medium water	5.1	44

8/16 -8/26/20

Table 3. Germination rate of irrigation treatments in the replicated subsurface drip trial.

Treatment	Average	Standard Dev.
	----- plants/ft ----	
Grower Standard	3.4	0.1
Low water	3.1	0.3
Medium water	3.3	0.1

Table 4. Untrimmed plant weight, final plant population, and biomass yield for the replicated drip germination trial.

Treatment	untrimmed plant wt. average	untrimmed plant wt. std. dev.	plant population at maturity average	plant population at maturity std. dev.	biomass yield average	biomass yield std. dev.
	lbs/plant		plants per acre		lbs/acre	
Grower standard practice	1.79	0.09	27852	720	49828	1955
Low water	1.90	0.07	26217	3531	49711	6113
Medium water	1.93	0.08	28397	327	54877	2761

Figure 1. Single use drip tape is injected a few inches below the soil surface so that it can be used to germinate up lettuce.

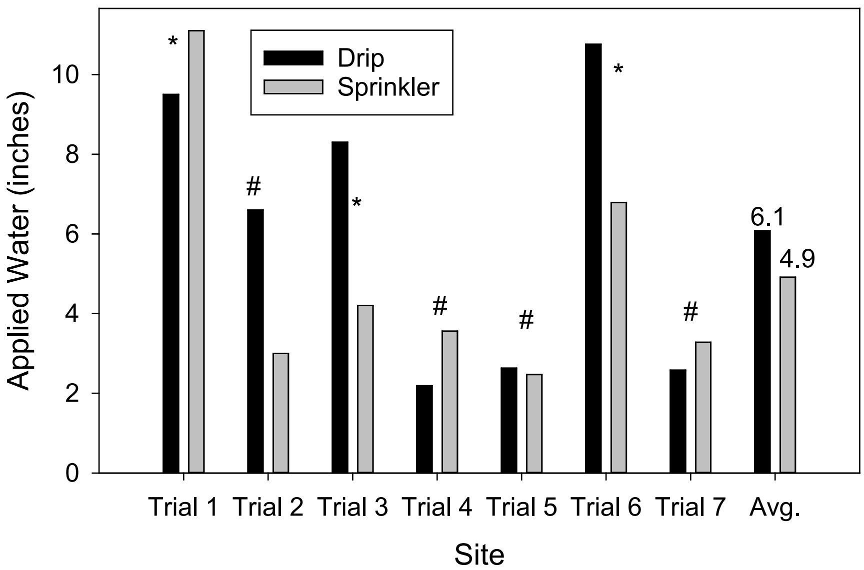

Figure 2. Water volume applied for germinating lettuce using single use buried drip and sprinklers in commercial fields (* sites with silty clay to clay loam textured soils, # sites with a sandy loam to silt loam textured soil).

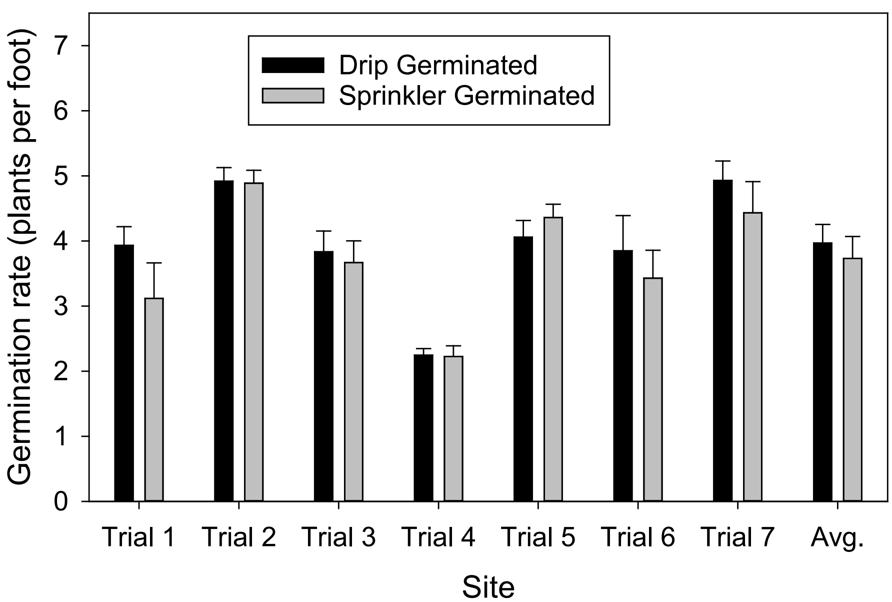

Figure 3. Germination rate before thinning for drip and sprinkler germinated lettuce.

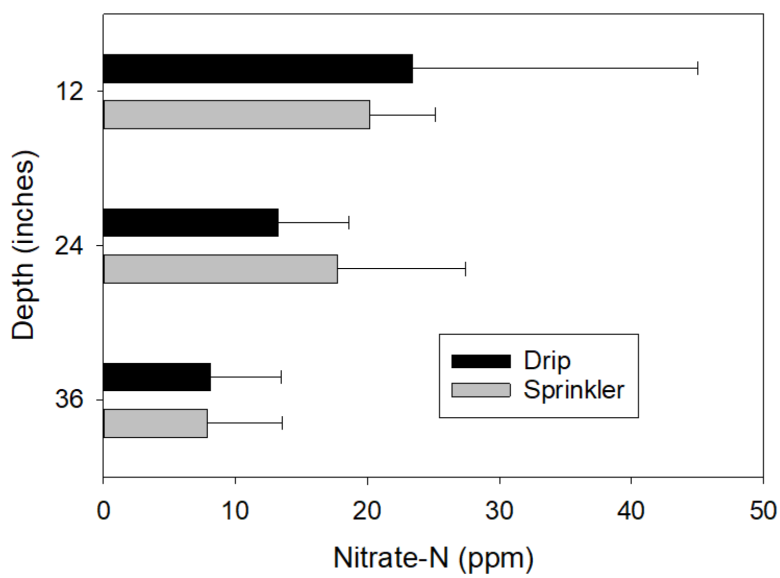

Figure 4. Distribution of nitrate in the soil profile after germination using drip or sprinklers.

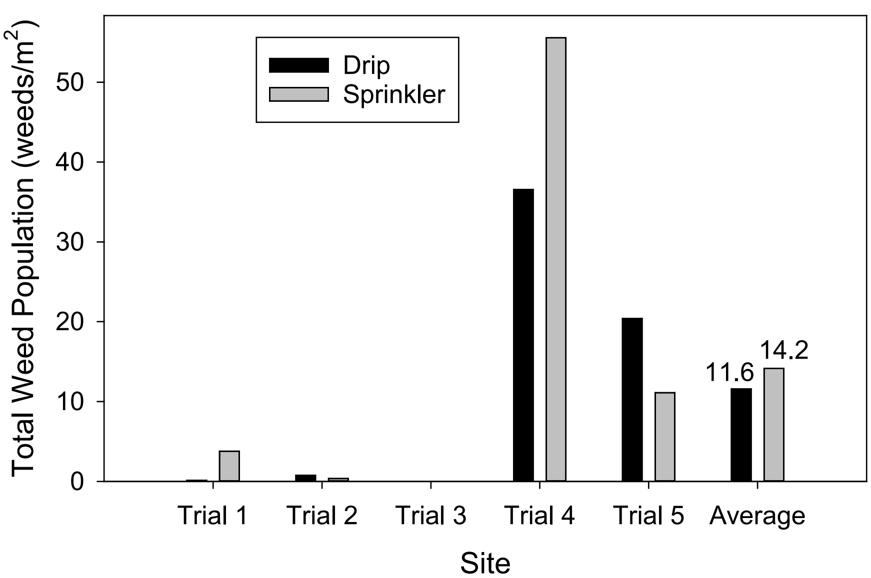

Figure 5. Weed population in lettuce after germination with drip or sprinklers.