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

Principal Investigators: Michael Cahn, Irrigation and Water Resources Advisor
University of California Cooperative Extension
1432 Abbott St.
Salinas CA 93901
mdcahn@ucanr.edu
O (831) 759-7377
C (831) 214-3690

Richard Smith, Vegetable and Weed Science Advisor
University of California Cooperative Extension
1432 Abbott St.
Salinas CA 93901
rifsmith@ucanr.edu
O (831) 759-7357

Abstract

The adoption of single-use buried drip tape has grown considerably in the Salinas Valley during the past few years. Potential advantages compared to using sprinklers for establishment followed by surface drip include eliminating the need and cost of overhead sprinklers, reduced surface runoff, reduced labor costs for extraction of drip tape, improved uniformity of applied water and injected fertilizers, and uniform germination and stand. Despite these benefits, single-use buried drip for lettuce may not be fully optimized. Over application of water during germination may cause leaching of residual soil nitrate. Growers may also be over irrigating during the germination phase to assure a uniform stand throughout their fields. Optimizing application uniformity of the drip system and soil preparation and tape installation may minimize water use for germination. This project continued evaluation of 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 fertilizer 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 as well as the effects on nitrate leaching and weed emergence.

Objective 3. Evaluate the use of pressure regulators and improved system design for increasing drip application uniformity. **Deliverable:** Evaluation of new types of pressure regulators that may be easier for implementing in vegetable operations and improve germination uniformity.

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 between sprinkler and drip germinated treatments at 9 commercial lettuce sites during 2020 and 2021. Either a portion of the field was germinated by sprinklers and a portion using buried single-use drip tape or adjacent drip and sprinkler germinated plantings were compared (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 the use of pressure regulators and improved system design for increasing drip application uniformity.* A simple survey will be administered to irrigators in Spanish to understand the reluctance to use pressure regulators to maintain a consistent pressure in the drip systems. We will evaluate several commercially available pressure regulators that potentially are simple for irrigators to operate and maintain and provide reliable regulation of pressure. At several field sites we will install pressure regulators (Fig. 2) and train the irrigators to operate them. We will also evaluate the uniformity of drip systems with and without pressure regulation, as well as the water use and germination uniformity. Near the end of the season we will administer a survey again to evaluate if the irrigators changed their opinion on using pressure regulators and to identify potential problems in implementing this practice in medium to large scale vegetable production operation.

Results

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 5 inches of water were applied during the first 10 days of the crop using sprinklers and 6.3 inches were applied for drip established lettuce (Fig. 3). 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 to germinate lettuce with drip at 3 of the 9 sites. Less water was used under drip than sprinklers at only 3 sites. Sites where the most water was used for drip germination (sites 1, 3, 6, and 8) had clay and clay loam textured soils that were well aggregated and large macropores which may have interfered with wicking moisture laterally across the bed 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 were 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 pressure (< 2 psi) at the end of the drip lines 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 soil moisture in the seed line than in areas 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 of drip germinated fields were generally equal or slightly better than germination rates in paired sprinkler germinated fields (Fig. 4). At only one site was the germination rate slightly lower under drip than under sprinklers (site 5).

Average soil mineral nitrogen (nitrate + ammonium) pre and post germination for paired sprinkler and drip germinated sites is presented in Fig 5. Approximately 45% of the initial mineral N in the soil was lost below 36 inches under drip. No loss of mineral N was detected in sprinkler germinated fields below 36 inches depth based on the pre and post germination soil N concentrations (Fig. 5).

Soil nitrate leaching was also evaluated in the replicated drip germination trial conducted in 2020 (described in objective 2). Similar to the results measured at the field sites, 45% to 60% of mineral N present at planting was lost during germination under drip (Table 2). Less mineral N was lost when less water was used for germinating the lettuce seed. However, the treatment with the lowest applied water amount (4.2 inches) still lost 45% of the mineral N below 24 inches.

Pressure regulating valves (PRV) were evaluated for reliability and ease of use with drip systems used in lettuce (Fig. 2). Netafim and Nelson Irrigation PRV for 4- and 6-inch pipe diameters were trialed in a commercial lettuce field. The 4-inch PRVs were unable to consistently regulate pressure of an 8-acre field because the flow rates of the irrigation system caused excessive pressure loss across the valve. Although the 6-inch Netafim PRV was able to accommodate the flow rate of the irrigation system it was found to be slow to respond to upstream changes in pressure and difficult for the irrigators to make adjustments. The Nelson 6-inch PRV (1000 series) not only could handle the flow rate of the drip system but was also easy for the irrigators to adjust and was found to react quickly to changes in upstream pressure. An additional problem that the irrigator survey identified and observed in practice, was that the irrigators were concerned that the layflat connecting the valve opener with the filter station would burst under pressures greater than 30 psi and therefore wanted to step-down the pressure to below 20 psi using the valve opener. Using the valve opener to also regulate the pressure interfered with the effectiveness of the PRVs to maintain a consistent pressure. Hence, we identified a type of layflat (red) that can withstand 100 psi of pressure which can be used at all connections before the pressure regulator.

Improved management practices for germinating lettuce with drip were evaluated in 5 additional field trials, where standard and improvement management treatments were compared in paired lettuce crops planted on similar dates and on similar soil types. At some trials, treatments were in adjacent plantings and only varied by planting date and management treatment. Improved practices included 1. using a pressure regulating valve to increase and maintain a consistent pressure throughout the irrigation, 2. Shortening the bed length of drip lines by placing the submain (layflat) one third of the distance from the edge of the upslope side of the field. 3. Carefully monitoring the irrigation system for leaks as well as soil moisture in the seedline, and taking action to correct identified problems. On average, applied water for germination using drip was reduced from 7 inches under the standard practice to 4.7 inches using improved practices, a 33% reduction in water use (Fig. 6). In all but one trial (trial 3) water use for germination was reduced compared to the standard practice. In this case, the drip tape was placed too deep in several beds located in the improved practice treatment and therefore extra water was needed to moisten the seed in these areas of the field. During the entire crop cycle total water use from planting to harvest was reduced from 15 inches under the standard practice to 11.2 inches, a 25% reduction in water use (Fig. 7).

Soil mineral N losses were compared for the improved and standard germination practices for trial 1, where 3.4 inches were applied for the improved management treatment and 10.8 inches were applied under the standard treatment (Fig. 8). The average N loss below the 36-inch depth was 83 lbs N per acre, or 26% loss under the improved management treatment, and 167 lbs per acre, or 79% loss under the standard management treatment. Note that the field where the improved management treatment was evaluated had 396 lbs N per acre before planting and the field where the standard practice was evaluated began with 210 lbs N per acre. These results as well as previous results discussed above would suggest that mineral N losses can be avoided by applying less than 3.5 inches of water to germinate lettuce using drip.

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 in 2021 and 2022as well as the UCCE Irrigation and Nutrient Meeting held in February, 2021.

Conclusions and recommendations

The commercial field evaluations demonstrated that current practices used by growers may limit potential water savings of single-use buried drip for germination and establishment of lettuce. Although 3 of the evaluation 9 sites were able to germinate crops with less than 3 inches of water, on average more water was used for drip germination compared to sprinklers. Germination rates were similar between the two irrigation methods, but soil mineral N losses were much greater under drip than under sprinklers. A greater amount of nitrate leaching is likely under drip because water is applied directly on the bed top rather than applied evenly on the bed tops and furrows, as would be the case using sprinklers. Also soil evaporation losses are presumably greater in sprinkler than drip germinated fields and would also be a factor in minimizing deep percolation and leaching losses.

The replicated trial as well as the trials comparing improved *vs* standard management demonstrated that water can be saved, and nitrate leaching reduced under 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. 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. Implementing these improved practices as well as using pressure regulating valves can greatly improve the ability to minimize water use and mineral N losses using drip under commercial field conditions.

Table 1. Summary of soil types and crop characteristics at drip *vs* sprinkler germination trial sites (2020 and 2021 seasons).

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
8	Mocho silty clay loam	crisphead	80	5	4/22/2021	4/30/2021	7/4/2021	5/4/2021
9	Cropley silty clay	romaine	40	2	4/22/2021	4/16/2021	7/2/2021	5/4/2021

Table 2. Water volumes and estimated mineral N lost below 24 inches for drip germination treatments in the replicated trial conducted in 2020.

Treatment	Applied water#	Mineral N loss	
	inches	lbs N/acre	%
Grower Standard	12.8	142	60
Low water	4.2	106	45
Medium water	5.1	126	53

8/16 -8/26/20

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

Figure 2. Pressure reducing valves were evaluated for maintaining optimal pressure in drip systems.

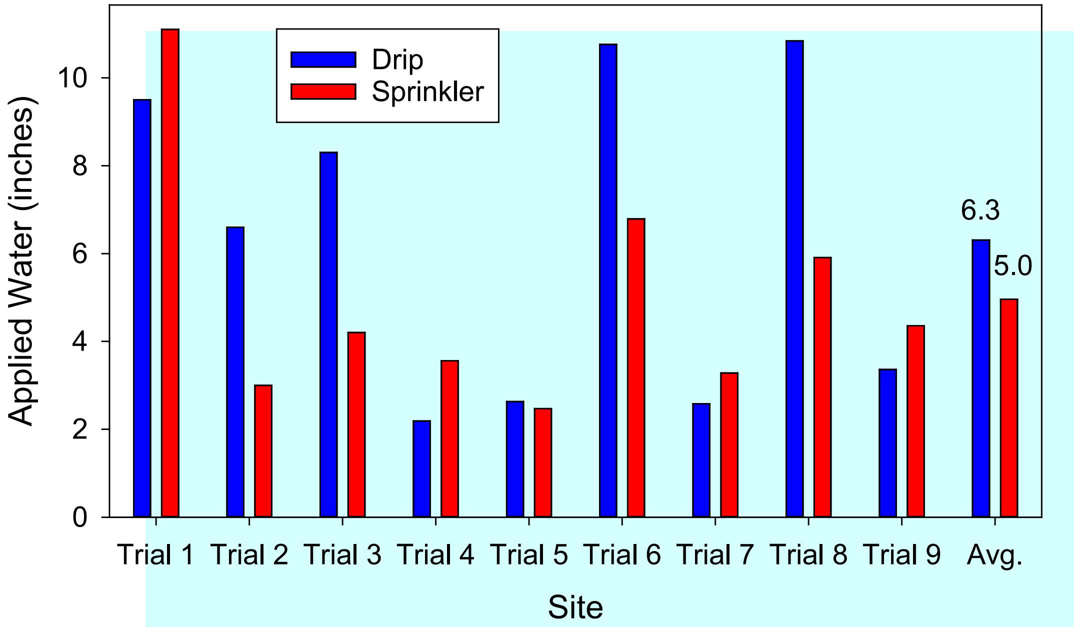


Figure 3. Water volume applied for germinating lettuce using single use buried drip and sprinklers in commercial fields.

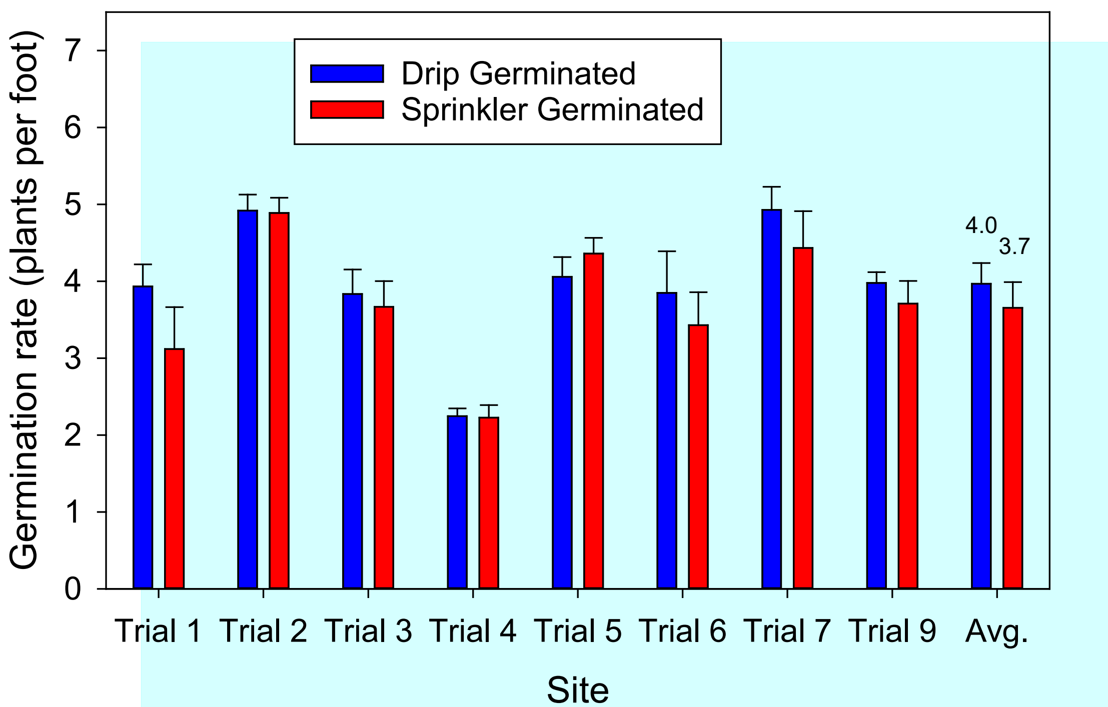
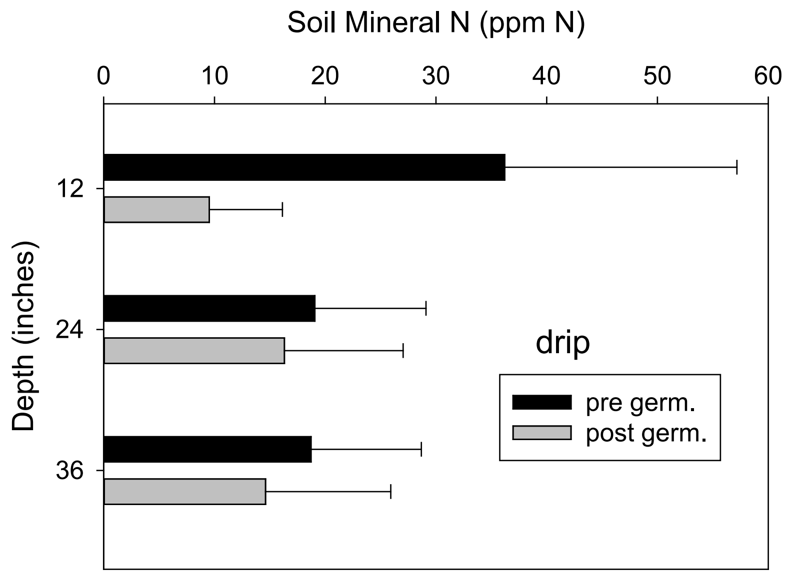


Figure 4. Germination rate before thinning for drip and sprinkler germinated lettuce.



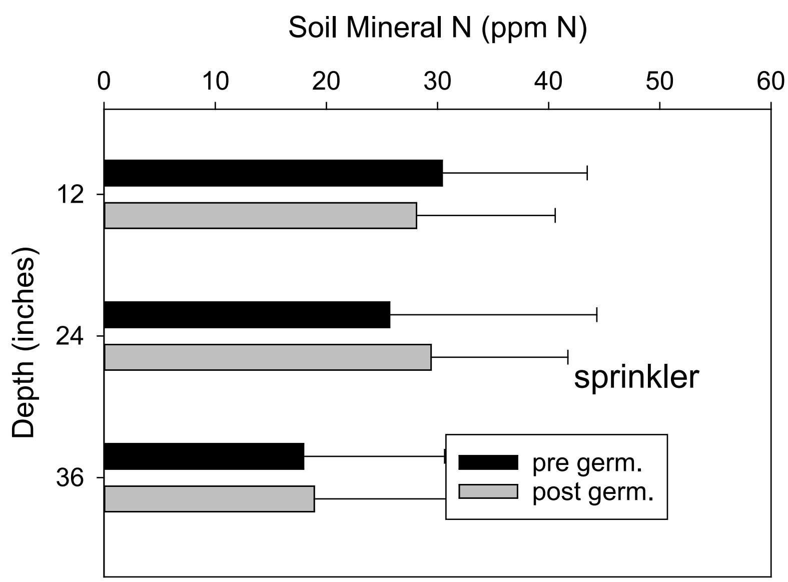


Figure 5. Average distribution of mineral nitrogen (Nitrate + Ammonium) in the soil profile before and after germination under drip and sprinkler for trials 3 - 9. Average drip applied water for germination totaled 5.8 inches and average sprinkler applied water for germination totaled 4.4 inches.

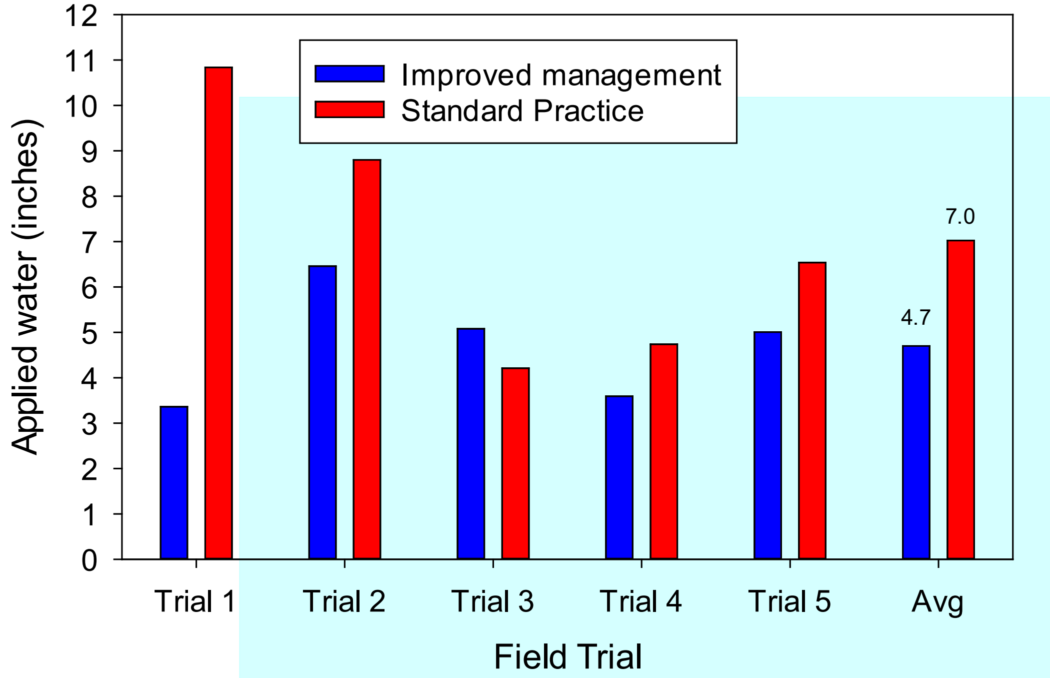


Figure 6. Comparison of applied water for drip germinating lettuce using improved and standard management (2021 season).

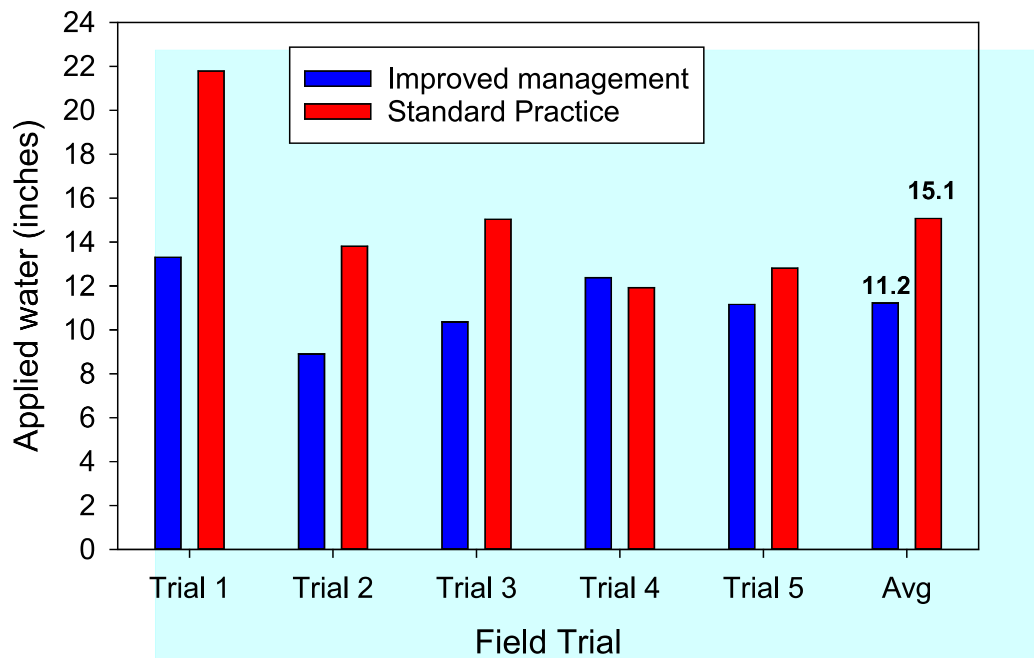


Figure 7. Comparison of total seasonal water used for drip germinated lettuce using improved and standard management.

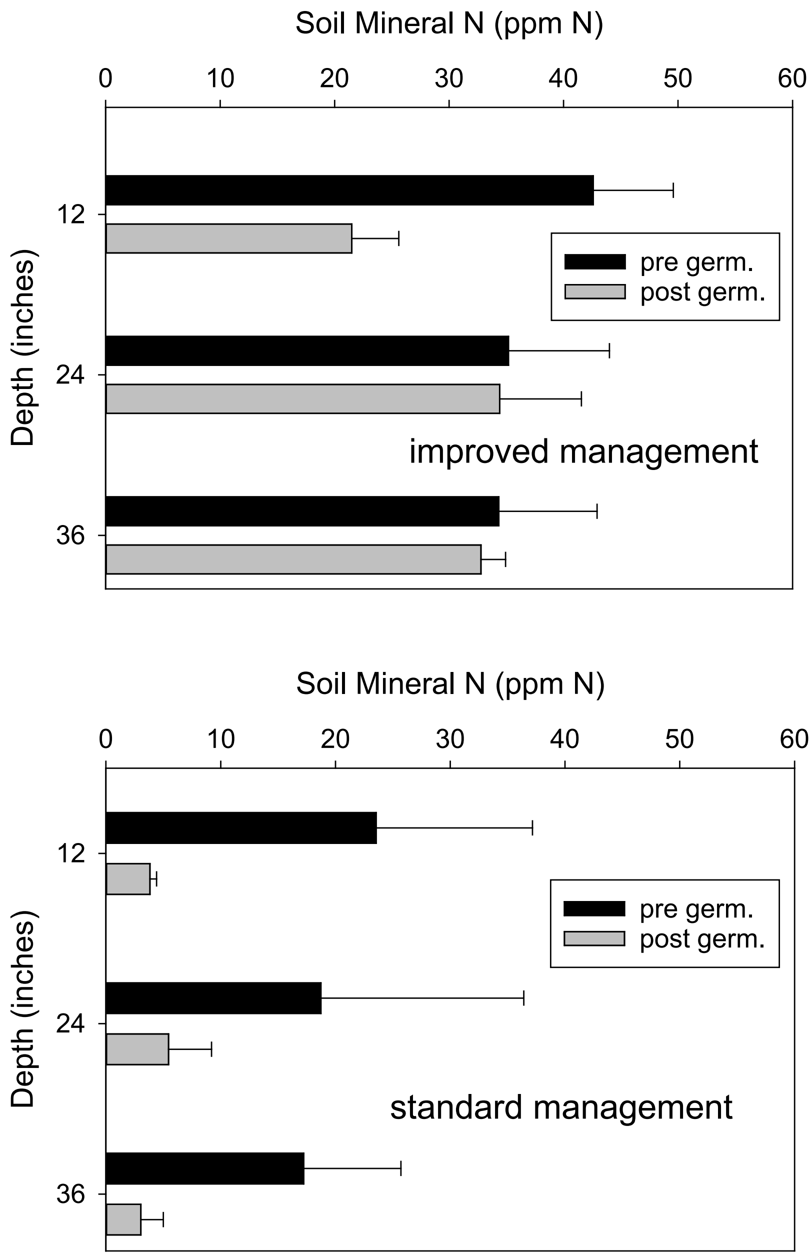


Figure 8. Distribution of mineral nitrogen (Nitrate + Ammonium) in the soil profile before and after germination under drip following improved and standard management practices. Drip applied water during germination totaled 3.4 and 10.8 inches for the improved and standard practices, respectively.