Project Title: The impact of irrigation and fertilizer management practices on enhancing resource-use efficiency in the low desert lettuce production systems.

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Abstract. The main objective of this study is to understand the viability and applicability of current irrigation and fertilizer management practices in the low desert lettuce production systems. The effort attempts to adapt the CropManage (CM) web-based tool for lettuce in the region. Four trials were conducted in four drip irrigated lettuce fields in the Imperial and Coachella Valleys from October 2022 through February 2023. A significant difference of plant density was estimated among the trial fields ranging from 24,830 to 65,340 plants per acre. Variable rates of water and N application were observed across the experimental sites. The amounts of water and N applied were greater at the iceberg lettuce fields than the romaine lettuce fields as well as in fields with sandy soil textures. A considerable difference (more than 240%) was found between the N and water application rates recommended by CM and grower practice at the field trials with sand-dominated soil textures. The findings of this two-year study suggested that lettuce growth could be maximized by seasonal N fertilization and irrigation water application rates below than current typical practices even in drip irrigated fields. However, more data from the ongoing replicated trials at the Desert Research and Extension Center may verify this preliminary conclusion. As a free decision-making tool, CM may assist local growers to maximize lettuce production and enhance the efficiency of N and water use.

Objectives. This study aims to develop information on irrigation and fertilizer management practices in the low desert lettuce production system. The effort attempts to adapt the CM web-based tool for lettuce in the low desert.

Procedures. The experiment was conducted in four commercial lettuce fields under subsurface drip irrigation in the Imperial and Coachella Valleys (Table 1). The trial fields 1 and 2 were germinated by drip and sprinklers were used to germinate the fields 3 and 4.

Table 1. General information of the trial fields.

Trial	Soil texture	Crop	Irrigation method	Wet date	Harvest date
1	Silty clay loam	Iceberg 80-in, 6 row	Drip	29 Oct, 2022	15 Feb, 2023
2	Silty loam	Romaine 80-in, 6 row	Drip	5 Nov, 2022	15 Feb, 2023
3*	Loamy fine sand	Iceberg 40-in, 2 row	Drip	9 Nov, 2022	21 Feb, 2023
4*	Sandy loam	Romaine 40-in, 2 row	Drip	29 Oct, 2022	18 Jan, 2023

*Trial fields 3 and 4 were switched to drip after plant establishment using sprinklers.

Fig. 1. A demonstration of the trial fields. The water applied was measured using magnetic flowmeter attached to datalogger. The data of water applied was automatically imported and analyzed by CM tool.

Due to logistical limitations, in each of the trial fields an assigned plot with an area of 300 feet by 300 feet was selected and all the measurements was conducted at the assigned plots (Fig. 2). Within the experimental assigned area of each field, five sub-areas (each will have an area of 50 feet by 50 feet) was determined for soil-plant samplings and monitoring the entire crop season.

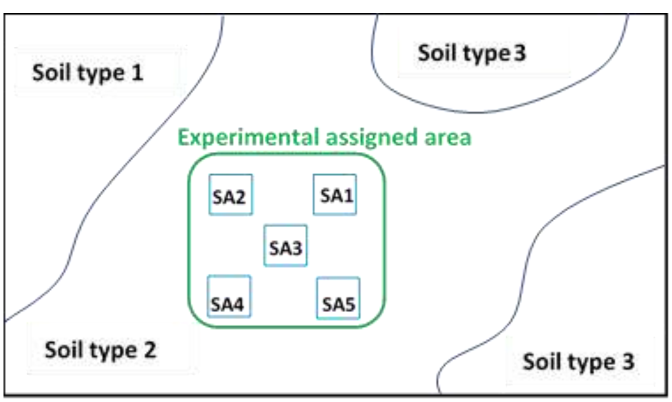


Fig. 2. Layout of a commercial experimental site (not to scale). The experimental assigned plot was selected in soil type 2. Sampling and monitoring were conducted in five sub-areas (SA1-SA5) over the crop season.

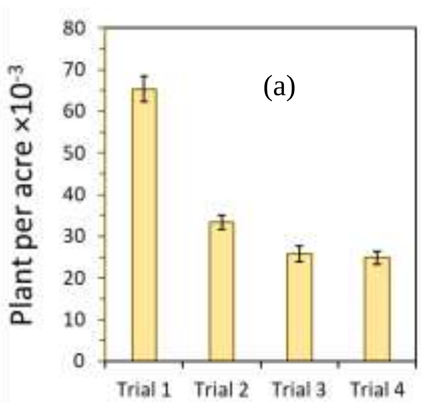
To develop a crop coefficient model based on canopy development, images were taken on weekly basis utilizing an infrared camera. The fertilizer applied were monitored throughout the crop season. The data of water applied was automatically imported and analyzed by CM web-based tool (Fig. 1). The actual soil nitrate content and the total N concentration in the plants were determined three times per season through laboratory analysis. Soil samples were collected from three depths (0-10", 10-20", 20-30"). In addition, soil quick N test was conducted from the top 10" of the soil in each trial field on a 10-day basis. A comprehensive yield quality data at commercial harvest stage was evaluated including plant population, head weight, biomass, and marketable yield. At harvest, total N, NO_3-N and dry matter concentration of head tissue were also determined.

Fig. 3. A demonstration of soil moisture and NDVI monitoring station at the trial field 4.

Results and discussion.

Plant density and canopy development: A considerable difference of plant density was observed among the trial fields (Fig. 4a). The maximum plant density was found at the trial field 1 (iceberg lettuce in 80-in bed) with a mean plant number per acre of 65,340. The minimum plant number was observed at the trial field 4 with a mean plant per acre of 24,830.

CM provided a good estimation of canopy % for both the iceberg and romaine trial fields (Fig. 4b). The SIMS model's estimations were not as good as CM.



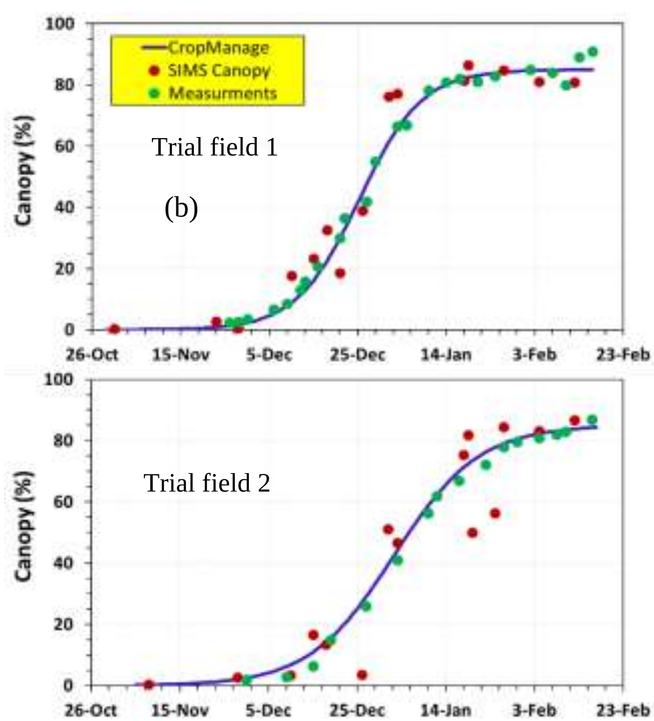


Fig. 4. (a) Mean plant density of the experimental sites. (b) A comparison of measured canopy cover % versus the estimated values by the CM and SIMS models.

<u>Assessment of water and nitrogen applied:</u> Variable amount of water and N application rates was observed at the experimental sites (Fig. 5). Overall, the amounts of water and N applied were greater at the iceberg lettuce fields as well as soil with sandy soil textures. For instance, the seasonal irrigation water was 20.8 inches at the iceberg lettuce field with a loamy find sand soil (trial field 3) while the value was 16.7 inches at the iceberg lettuce field with a silty clay loam soil (trial field 1). The trial field 4 (romaine lettuce in a sandy loam soil) received 3.2 inches water more than the trial field 2 (romaine lettuce in a silty loam soil). A substantial difference was found between the N application rates recommended by CM and grower practice at the field trials with sandy soil textures.

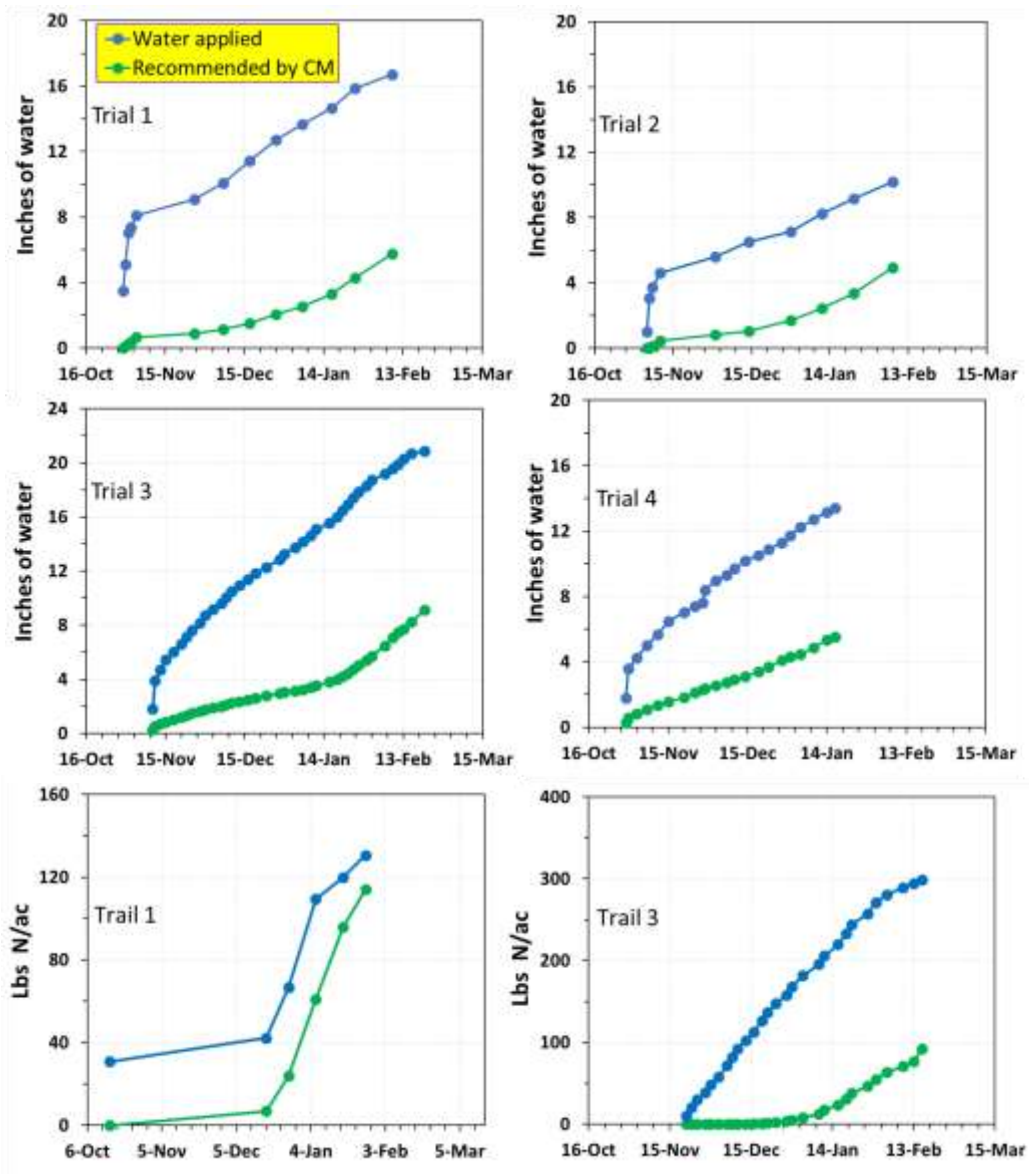


Fig. 5. Cumulative water and N applications across the experimental sites.

Soil NO_3-N: Across the four trial fields, the average soil NO_3-N concentration in the top one foot varied from 17.7 mg kg^{-1} or ppm (trial 4) to 55.5 (trial 2) mg kg^{-1} at post-thinning and ranged between 9.3 mg kg^{-1} (trial 3) and 77.5 mg kg^{-1} (trial 2) at harvest (Table 2). A higher level of plant tissue N% was observed at the trial fields 3 (3.9%) and 4 (3.4%) than the trial fields 1 (3%) and 2 (2.7%).

Mean biomass N and seasonal applied N: Across the trial fields, seasonal N application rates (including preplant fertilization) varied from 101 $lbs.ac^{-1}$ in a romaine lettuce field (trial field 2) to 298 $lbs.ac^{-1}$ in an iceberg lettuce field (trial field 3) (Table 2). A wide range of biomass N was found among the trial fields varied from 82 $lbs.ac^{-1}$ in a romaine lettuce field (trial field 4) to 158 $lbs.ac^{-1}$ in an iceberg lettuce field (trial field 1).

Table 2. Seasonal N applied, lettuce fresh biomass and N in the trial fields.

Trial field	Soil NO3-N at post-thinning (ppm) (1-ft)	Seasonal N applied (lbs. ac^{-1})	Mean Lettuce fresh biomass ($ton.ac^{-1}$)	Mean Biomass N (lbs. ac^{-1})	Soil NO3-N at harvest (ppm) (1-ft)
1	50.1	131	56.4	158	59.3
2	55.5	101	30.6	88	77.5
3	19.8	298	35.1	141	9.3
4	17.7	209	28.4	82	12.2

A low level of residual soil NO_3-N in the topsoil at harvest and considerably less N uptake than N applied suggested inefficient use of N fertilization at the trial fields with light soils. The results indicated that leaching nitrate could be problematic at the sites with sandy soil texture, however, a better N management may reduce the issue.

The findings of this two-year study suggested that lettuce growth could be maximized by seasonal N fertilization and irrigation water application rates below than current typical practices even in drip irrigated fields. However, more data from the ongoing replicated trials at the Desert Research and Extension Center may verify this preliminary conclusion. As a free decision-making tool, CM may assist local growers to maximize lettuce production and enhance the efficiency of N and water use.