EFFICIENCY OF IRRIGATION METHODS FOR STRAWBERRIES

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Abstract. **Trickle, overhead sprinkler and furrow irrigation methods were compared in a strawberry production experiment. Rainfall during the season was above normal. Yield and size of fruit were not affected by irrigation method. Irrigation method was a significant factor with regards to movement of soluble salts in the bed. Movement of salts was towards the upper center part of the bed for the sprinkler and furrow methods, while significant movement was not detected for the trickle method. Soil moisture content in the rooting zone was maintained near field capacity on a continuous basis by the trickle method, while the sprinkler and furrow methods were effective in returning the soil moisture content to field capacity when applications were made, but this was followed by a gradual depletion to almost soil moisture level of the unirrigated treatment before the next application. Approximately one half the quantity of water was used for the trickle method as compared to the sprinkler and furrow methods.**

Irrigation and other intense cultural practices are commonly used on high value crops such as strawberries. Overhead sprinkler is the standard irrigation method used in Florida. During recent years, interest has increased in applying irrigation water by the trickle method. This method, also called "drip" or "daily flow" method, embodies the concept of preventing moisture stress in at least a portion of the root system by the daily application of water to only part of the field area (2). The distribution system applies water to irrigated areas daily, at slow rates and with low pressures. Among the potential advantages of this method are (1) water conservation (2) increased yields (3) safe use of poor quality (high saline) water and (4) smaller pumping plant (1,3).

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Strawberries appear to be a crop that is rather well suited to trickle irrigation. They are grown on bedded soil, covered with polyethylene mulch, which cannot be wetted directly and must depend upon capillary forces to transfer moisture into the soil beds (5).

This study was conducted to determine the effects of sprinkler, furrow and trickle irrigation methods on strawberry production, efficiency of irrigation water utilization, soil moisture distribution in the beds and movement of soluble salts in the beds.

Materials and Methods

During the 1971-72 season, five irrigation methods were evaluated on strawberries near Gainesville. The soil used was a Kanapha fine sand with a water table that fluctuated from near the soil surface down to about three feet. Treatments were arranged in a randomized complete block design with four replications. Each plot consisted of three beds, 30 feet in length, spaced four feet on centers. Data were taken from the center row of each three row plot. "Tioga" plants were set on beds in double rows 12 inches apart with a plant spacing of 12 inches. Treatments were as follows: (1) overhead sprinkler (2) furrow (3) double-wall hose trickle (4) porous polyethylene fiber hose trickle and (5) unirrigated check. Spray head sprinklers of the strip type were used to distribute water for the sprinkler treatment. One conter and two end strip spray heads were used on each plot row to provide an application rate of approximately 0.71 inch per hour. For furrow irrigation, the furrows on each side of the center row of the plot were irrigated at a rate of 1.1 gpm per furrow. The application rates exceeded the infiltration rate by a factor of about two for both the sprinkler and the furrow treatments making it necessary to dam the ends of the furrows to prevent water loss as surface runoff. Water in the furrows was approximately four inches deep when irrigation was completed. The double-wall hose for trickle distribution was made of polyethylene plastic with small perforations in the outer hose about one foot apart for water discharge. The application rate was about 4.8 gallons per hour for a 30 foot length of hose (0.13 inch per hour for two foot wide strip). Operating pressure was 1.5 psi. The porous polyethylene fiber hose system allows the passage of water through micron-size pores in the hose material. Water seeps from the hose into the soil at a rate of approximately 0.67 gallons per hour for a 30 foot length of hose (0.02 inch per hour for two foot wide strip). Operating pressure was 5.0 psi. The hoses for both of the trickle systems were laid on the soil surface under the plastic mulch and extended along the top of the beds between the two rows of plants.

Irrigation management depended upon estimated consumptive use and irrigation was applied weekly (unless rainfall interrupted the sequence) for the sprinkler and furrow treatments, and daily for the two trickle treatments. Consumptive use estimates were based on the modified Blaney-Criddle formula (6). The formula may be written:

$$u = \frac{k_c tp\ (0.0173t - 0.314)}{100}$$

where:

- u = estimated consumptive use for strawberries in inches per month
- k_c = a coefficient reflecting the growth stage of the crop
- t = mean monthly air temperature, F
- p = monthly percentage of daylight hours in the year

Solution of the equation for strawberries grown at Gainesville gives an estimated consumptive use of 1.84, 1.84, 1.95, 2.93, 3.77 and 5.06 inches for the months December through May. Two other assumptions were made to arrive at the quantity of water to be applied. One was that the overall irrigation efficiency (quantity of water delivered to the plot/quantity placed in the soil of the rooting zone) would be 65% for sprinkler, 60% for furrow and 90% for each of the trickle methods. The other was that the entire plot area would be irrigated by the sprinkler and furrow methods while only ½ of the plot area would receive water by the trickle methods. In estimating the accumulated soil moisture deficit, daily rainfall in amounts of less than 0.1 inch was ignored and for the trickle systems, applications were not made on days with significant railfall (0.1 inch or more) or the following day.

Fruits were harvested biweekly, graded and weighed. Yields are reported as number of marketable 12-pint flats per acre and average weight per fruit in grams.

Soil samples were taken at the end of the season at depths 0 to 2 inches, 2 to 4 inches and 4 to 6 inches from the center and the side of the beds for soluble salt determinations. Saturated paste extracts were prepared and used for analysis for soluble salts (4). Results are expressed in ppm based on soil weight.

Results and Discussion

Rainfall for the growing season was above normal. Unirrigated plants manifested minor drought symptoms on two occasions, once during the latter part of March and again about April 20. A total of five irrigation applications were made during March, April and May for the sprinkler and furrow treatments. Water was applied through the trickle system on 48 of the 64 days between March 1 and May 3. Total water applied was 2.99 inches for each of the trickle systems, and 6.52 and 7.19 inches for the sprinkler and furrow treatments, respectively.

Yield and fruit size were not significantly influenced by any of the irrigation methods. Production values for the season are given in Table 1. It was thought that production for the drier period (late April) possibly would have been influenced by irrigation, but a separate analysis of production for the period April 14-28 also indicated treatment differences did not exist. It is apparent that droughts producing greater plant stresses than those of the 1971-72 season are necessary to evaluate irrigation methods with field plot experiments in terms of yield responses.

Soil samples taken on May 15, at the end of the season, indicate that irrigation method significantly influenced soluble salt movement in the bed (Table 2). Because of similar responses by some of the irrigation methods, it is convenient for interpretation purposes to consider irrigation

Table 1. Influence of irrigation method on fruit yields.[a]

Method	Yield Flats/A	Yield g/fruit
Overhead Sprinkler	1355	12.7
Furrow	1230	12.4
Trickle, Double-Wall Hose	1182	12.0
Trickle, Porous Fiber Hose	1218	12.0
Unirrigated Check	1172	12.5

[a]Yield difference due to irrigation method not significant at the 5% level.

Table 2. Effect of irrigation method on soluble salt levels in the bed at the end of the fruiting season.

Irrigation Method	Sample depth 0-2"	2-4"	4-6"
	Bed Center - ppm Soluble Salts		
Overhead sprinkler, furrow, and unirrigated check	637[a]	241	217
Trickle (both methods)	190	167	163
	Bed Side - ppm Soluble Salts		
Overhead sprinkler, furrow and unirrigated check	286	200	182
Trickle (both methods)	179	157	168

[a]Difference between method groups at the 0-2" depth at bed center is significant at the 1 percent level.

methods as two groups. One group contains overhead sprinkler, furrow and unirrigated check and the other contains the two trickle methods.

The highest salt concentration, averaging 637 ppm, was found in the bed center at 0-2 inch depth for the overhead sprinkler, furrow, and unirrigated check grouping of irrigation methods. The difference between groups of irrigation methods is highly significant at bed center at the shallowest depth. Soluble salt levels were much lower, averaging only 225 ppm, at other sampling locations in bed center.

With the two trickle irrigation methods soluble salt concentration averaged 171 ppm but there were no significant differences in levels for the six sample locations. These findings agree with previously reported results (5) of soluble salt accumulations in beds under polyethylene mulch where moisture must enter the bed from below. *It is suspected* that lower soluble salt concentrations in the upper center part of the bed for the trickle irrigation methods is the result of irrigation water moving into the beds from above. In a drier season, these differences in soluble salts concentrations would be expected to be greater and may have a depressing effect on fruit yields.

Soil moisture contents were measured in soil zones "A" "B" and "C" (Figure 1) on the days before and after irrigations made on April 20 and May 3. Results of these measurements are given in Table 1. Values in the table reflect adjustments made for estimated water use for the two day time period between the "before" and "after" soil samplings.

The soil moisture content values for the unirrigated check treatment indicate the depletion level in zone "A" was only about 1/3 on April 20 and 1/4 on May 3. These dates coincide with two of the drier periods of the growing season and the soil moisture levels for the unirrigated treatment are indicative of the absence of significant drought conditions. The average soil moisture deficit in zones "A," "B" and "C" combined for the sprinkler and furrow treatments on April 20 and May 3 was only about 0.5 inch. By comparing the actual deficit of 0.5 inch with the expected deficit of 0.88 inch for April and 1.14 inches for May, it becomes apparent that the Blaney-Criddle formula was misapplied in this situation. The close proximity of the water table to the soil of the rooting zone and the moisture conserving influence of the polyethylene mulch are suspected as being major factors in causing the depletion rate to be slower than anticipated.

Both sprinkler and the furrow methods were reasonably effective in replenishing moisture in the soil under the plastic mulch. The sprinkler method was more effective in this respect than the furrow, possibly because a portion of the sprinkler applied water entered directly into the soil of the bed through perforations in the mulch where the plants were set. The double-wall hose trickle system was effective in returning the soil moisture level to field capacity or above in zones "A" and "B" combined each day. The same is probably true for the porous fiber hose trickle system, however, the data in Table 3 indicates the soil moisture level to be slightly below field capacity. Time of sampling in relation to the time of application for the trickle systems accounts for this discrepancy. Samples were taken about one hour after application had begun for both trickle treatments and at that time the double wall pipe system had almost completed its daily application while the

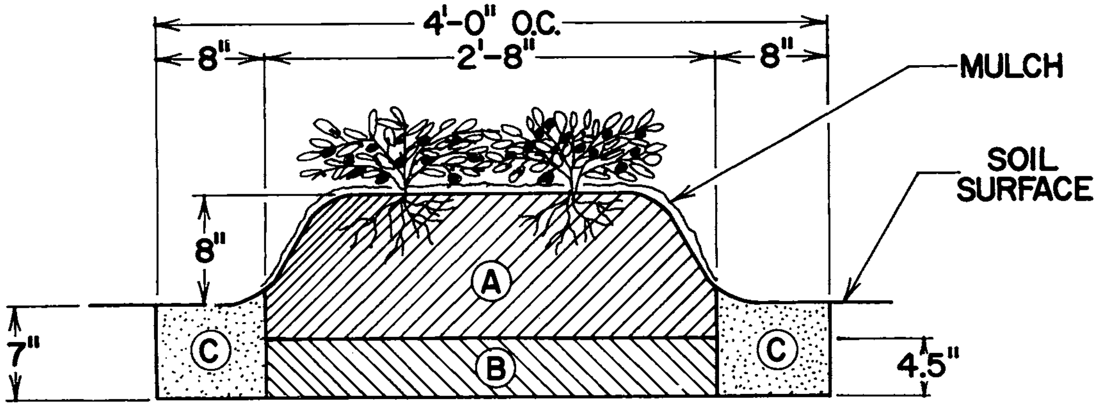

Fig. 1. Cross section of bed indicating location of zones for soil moisture measurements.

Table 3. Influence of irrigation method on soil moisture content, 1972.

Irrigation method	Zone of samples 1/	Percent of field capacity Before irrigation	After irrigation
	April 20 Irrigation		
Overhead sprinkler	A	79.9	103.0
	ABC 2/	84.7	104.6
	C	89.0	108.5
Furrow	A	66.7	94.0
	ABC	76.7	100.5
	C	82.2	101.9
Trickle double-wall	A	109.2	106.2
	ABC	103.6	102.1
	C	90.9	94.9
Trickle Porous fiber hose	A	88.8	94.6
	ABC	87.7	95.9
	C	76.9	86.4
Check unirrigated	A	68.8	66.4
	ABC	75.5	77.9
	C	76.9	76.7
	May 3 Irrigation		
Overhead sprinkler	A	84.2	97.6
	ABC	91.1	101.9
	C	95.0	110.3
Furrow	A	75.8	86.1
	ABC	79.0	91.8
	C	73.8	110.5
Trickle double-wall	A	133.8	106.8
	ABC	118.8	106.3
	C	86.5	94.6
Trickle porous fiber hose	A	97.9	97.0
	ABC	98.8	99.9
	C	95.4	95.8
Check, unirrigated	A	76.8	76.8
	ABC	82.4	81.4
	C	76.5	78.2

1/ See Figure 1 for description of zones.

2/ ABC refers to zones, A, B, and C combined.

porous fiber pipe system had applied only about 1/7 of its daily application. Rate of application for the double wall pipe system is approximately seven times faster than the porous fiber pipe system. Regardless, soil moisture tensions were quite low at all times for both trickle systems.

The assumption that the trickle systems would apply water to only ½ of the plot area was not valid. The moisture content of soil in zone "C" is considerably higher for the trickle treatments than for the check (Table 3). The obvious conclusion is that lateral movement of irrigation water in the soil was a least 2 feet and that both trickle systems were irrigating a strip of soil at least 4 feet in width.

The scheme of management for an irrigation system is a major factor in influencing the functional performance of the system. The four types of systems used in this study were each managed so as to typify their use for strawberry production in Florida. The results of this study would have been different if other management schemes had been used. The trickle types maintained a higher average soil moisture content in the rooting zone and required less than ½ the quantity of water as the sprinkler and furrow systems for the period of this study.

A general conclusion, based on data in Table 3, is that the soil moisture content in the rooting zone was maintained close to field capacity on a continuous basis by each of the trickle methods, while the sprinkler and furrow methods were effective only in returning the soil moisture to field capacity on the day of application which was then followed by a gradual depletion almost to the deficit level of the unirrigated treatment before the next irrigation was made.

The distribution systems for all the irrigation types used in this study were operationally functional during the entire experiment and significant management problems were not experienced.

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