Contrary to other reports with highbush blueberry plants (3, 5) machine harvesting or rabbiteye blueberry plants caused very little plant damage. The amount of plant damage noted both years was so minor that the results are not presented.

The tests reported here indicate that rabbiteye blueberry growers should prune their plants for machine harvest, grade fruit very carefully, and either have a ready, fast market for machine-harvested fruit or not move machine-harvested fruit into the fresh market.

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Frequency and Rate of Fertilization with Trickle Irrigation for Strawberries[1]

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Abstract. **Strawberry (*Fragaria* X *ananassa* Dutch.) response to trickle irrigation was compared with overhead and no irrigation. Fertilizer rates were 94-55-104 to 202-118-223 kg/ha N-P-K with 0, 50, and 100% of the N and K applied with trickle irrigation. The remaining fertilizer for trickle and all for overhead and non-irrigated treatments was applied preplant. Fruit yields were increased 34% with overhead irrigation and 37% with trickle irrigation above that for non-irrigated treatments. With 0 and 50% of the N and K applied in daily or weekly increments with trickle irrigation, fruit yields were 2 and 20% greater than with overhead irrigation, 30 and 58% greater than with no irrigation, respectively. The N levels of leaf tissue samples were not influenced by treatment. Leaf K levels were significantly higher with trickle irrigation than with overhead irrigation or check treatments. Soil value for total soluble salts, K and NO_3 were significantly lower with trickle irrigation than with overhead or no irrigation treatments.**

Strawberry requirements for both supplemental N and K are about 100 kg/ha when grown on Florida sandy soil with polyethylene mulch by the annual hill system (1, 9). Irrigation is generally used and overhead irrigation provides higher production than furrow irrigation (8, 12). During the season, soluble salts accumulated in the bed with both irrigation methods (10) and in the proportion to the amount of water applied (12). Transplanted strawberries are very sensitive to excessive soluble salts, and salt accumulation near the soil surface is detrimental to plant growth (3). Recent studies with strawberries have shown that soluble salt accumulation can be minimized with trickle irrigation and that a constant and low-water stress can be maintained with one-half as much water as that required for overhead irrigation (10). Maximum response of tomatoes to trickle irrigation, however, requires the application of supplemental fertilizer with the water (7).

Studies reported here were conducted with strawberries to evaluate water rates, fertilizer rates, and timing of N and K application with trickle irrigation.

Materials and Methods

Three irrigation methods, trickle, overhead, and no irrigation, were evaluated on strawberries grown on Blichton fine sandy soil located near Gainesville during the 1973-74 and 1974-75 seasons. During the 1973-74 season, trickle irrigation treatments were applied in a factorial experiment with factors as follows: 1) water rate of 34 and 48% that of overhead; 2) fertilizer rates of 94-55-104 and 135-78-149 kg/ha N-P-K; and 3) method of fertilizer application, (a) 50% N and K and all P applied preplant broadcast and 50% of the N and K applied with the trickle irrigation, and (b) all fertilizer applied preplant broadcast. During the 1974-75 season, trickle irrigation was evaluated with factors as follows: 1) fertilizer rates of 135-78-149 kg/ha and 202-118-223 kg/ha; 2) 0, 50, and 100% of the N and K applied preplant incorporated with the remainder applied with trickle irrigation (all P was applied preplant), and 3) daily and weekly application of the N and K applied with the trickle irrigation. In both seasons, overhead and no irrigation treatments were also used with the above fertilizer rates. Factorial treatments were arranged in a randomized block design with four replications. Plots were single beds spaced 1.22 × 7.63 m apart with a border bed provided between each treatment. In early Oct. of each season, preplant fertilizer was applied broadcast as ammonium nitrate, ordinary superphosphate, and potassium sulfate. Beds were then made with a rototiller and bed-press. Bi-wall (Anjac) trickle irrigation hose was placed in the center of appropriate beds. Black polyethylene mulch was then applied over the beds. 'Tioga' runner plants were planted in double rows spaced 30.5 cm apart and 30.5 cm apart within each row, on Oct. 18, 1973, and October 31, 1974.

Irrigation management was based upon an estimated con-

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sumptive use for Gainesville as determined by the Modified Blaney-Criddle equation (2). When rainfall was less than the estimated consumptive use, water was applied to the overhead sprinkler treatment every 6 to 7 days. In 1973-74, the trickle-irrigated plots received fertilizer weekly and water daily except when rainfall was sufficient. In 1974-75, fertilizer was applied daily and weekly with trickle irrigation and water was applied daily by trickle irrespective of rainfall. Fertilizer from ammonium nitrate and potassium sulfate was dissolved in water for injection into the trickle lines.

During the 1974-75 season, soil and leaf samples were taken on Feb. 7 (flowering), March 27 (mid-harvest), and April 22, 1975 (late harvest). Soil samples were taken from each side of the bed in the plant row to a depth of 15 cm. Saturated paste extracts (11) were made and total soluble salts, NO_3-N, P, and K were determined (6) and expressed as ppm at 10% soil moisture (−.06 bar). Leaf samples were taken from recently mature leaves and N was determined by the Kjeldahl method, P colorimetrically (molybdate complex), and K by flame photometer (6). Fruit were harvested bi-weekly and began on January 29, 1974, and on February 20, 1975, and continued through May of each season.

Results and Discussion

For strawberries grown in Gainesville, the calculated monthly water consumptive use (1) ranged from 4.67 to 12.85 cm per month (Table 1). During both seasons, the estimated water needs for a number of months were not met by rainfall during the mid- and late-fruiting periods. In some months when rainfall exceeded estimated water needs, most of the rainfall occurred in one or two weeks. In each season, 16 overhead sprinkler applications were used while 145 and 173 trickle applications were made during the two seasons, respectively. Effects of water rate, fertilizer rate, and method of fertilizer application with trickle irrigation influenced yield and nutrient composition independently, therefore, only main effects are presented.

Strawberry yield increased significantly (about 10%) during the 1973-74 season with an increase in the N-P-K fertilizer rate (kg/ha) from 94-55-104 to 135-78-149. An increase in the fertilizer rate from 135-78-149 to 202-118-223 during 1974-75 had no significant effect on yield with any of the irrigation methods.

Table 1. No. of irrigation applications and amount of water (cm), water needs, and rainfall in the 1973-74 and 1974-75 seasons.

Month	Irrigation application: Trickle 1 No.	Trickle 1 cm	Trickle 2 No.	Trickle 2 cm	Overhead No.	Overhead cm	Water[z] needs cm/mo	Rainfall cm/mo
				1973-74				
Dec.	18	0.89	18	1.47	1	1.22	4.67	13.06
Jan.	31	1.47	31	2.57	4	4.88	4.67	0.91
Feb.	22	1.32	22	1.88	1	2.44	4.95	8.03
Mar.	29	2.74	29	3.07	3	7.32	7.44	6.12
Apr.	30	3.56	30	4.98	5	12.19	9.58	2.51
May	15	2.13	15	2.90	2	7.32	12.85	18.47
Total	145	12.11	145	16.87	16	35.37	44.16	49.10
% of overhead		34		48		100		
				1974-75				
Nov.	14	1.22			3	7.32	4.67	1.42
Dec.	30	2.74			1	1.22	4.67	15.77
Jan.	31	2.84			2	2.44	4.67	9.80
Feb.	28	2.97			1	1.22	4.95	11.99
Mar.	30	5.41			2	7.32	7.44	6.78
Apr.	30	8.15			5	17.07	9.58	11.46
May	10	2.74			1	3.66	12.85	3.15
Total	173	26.07			16	40.25	48.83	60.37
% of overhead		65				100		

[z]Calculated (2).

Table 2. Main effect of irrigation method on early and total marketable yield of strawberries.

Irrigation method	Early fruit[z] no./ha 1000	Early fruit[z] kg/ha 1000	Early fruit[z] Size (g/fruit)	Total fruit no./ha 1000	Total fruit kg/ha 1000	Total fruit Size (g/fruit)
			1973-74			
Trickle	411a	4.87a	11.84a	1601a	16.34a	10.20a
Overhead	395b	4.34b	10.98b	1562a	15.14a	9.68b
Check	349b	3.73c	10.68b	1106b	10.60b	9.60b
			1974-75			
Trickle	944	11.13a	11.97a	1779a	18.85a	10.64a
Overhead	981	9.86b	10.47b	1755a	16.83b	9.77b
Check	806	8.76b	10.85b	1379b	13.80c	10.00b

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

The main effects of irrigation method on fruit yields were significant in both seasons (Table 2). Early fruit yields were significantly greater in the 1973-74 season with overhead irrigation than with no irrigation. In both seasons, early yields were significantly greater with the trickle treatment than with either the overhead or the no irrigation treatments. Effects of irrigation method on total yield were also significant. During the 1973-74 season, the total weight of marketable fruit was 43% greater with overhead and 54% greater with trickle irrigation than with the non-irrigated treatments. During the 1974-75 season, yield increases were 22% and 37% greater for overhead and trickle irrigation, respectively, than the check treatment. Fruit size was also significantly greater with trickle irrigation than with overhead or the non-irrigated treatments. No difference in fruit yield due to the rate of water applied with trickle irrigation was obtained in the 1973-74 season. Yields were similar with trickle applications of 12.1 cm and 16.9 cm of water during that year.

Both the amount and timing of N and K application with the trickle irrigation had no effect on early yield, but did significantly influence total yields in both seasons (Table 3). Total number and weight of marketable fruit were significantly higher with 50% of the N and K applied with the trickle irrigation than where all fertilizer was applied preplant. Further increases in the N and K applied by trickle to 100% resulted in yields greater than with 100% preplant fertilization, but lower than treatments with 50% N and K applied with trickle irrigation. No difference in early or total yield was obtained where the N and K was applied either daily or weekly with trickle irrigation.

Table 3. Main effect of amount and timing of N and K applied with trickle irrigation on total marketable yield of strawberries in two seasons.

Application of N and K with irrigation	Total fruit[z] no./ha 1000	Total fruit[z] kg/ha 1000	Total fruit[z] Size (g/fruit)
Amount		*1973-74*	
0%	1474b	14.73b	9.98b
50%	1728a	17.94a	10.42a
		1974-75	
0%	1508c	16.49c	10.91
50%	1902a	20.47a	10.76
100%	1794ab	18.42b	10.38
Frequency			
None	1508b	16.49b	10.91
Daily	1806a	19.50a	10.78
Weekly	1888a	19.39a	10.37

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. Main effects of amount and frequency of N and K applied with trickle irrigation and irrigation method on soil soluble salt and K levels during the 1974-75 season.

	Soil value (ppm)					
	Soluble salts			K		
Treatment	Feb. 7	Mar. 27	Apr. 22	Feb. 7	Mar. 27	Apr. 22
N & K applied with trickle irrigation						
0%	833	560b	565	98c	55c	56c
50%	955	684ab	764	127b	75b	99b
100%	1144	846a	906	164a	125a	143a
Frequency by trickle						
None	833	560b	565	98c	55b	56b
Daily	1052	762a	884	122b	100a	135a
Weekly	1046	768a	786	170a	101a	107a
Irrigation method						
Trickle	1006b	724b	781c	137b	91b	108b
Overhead	2032a	1205a	1930b	201a	113ab	181a
Check	2202a	1365a	2710a	214a	130a	230a

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 5. Main effects of amount and frequency of N and K applied with trickle irrigation and irrigation method on leaf tissue composition of samples taken during the 1974-75 season.

	Leaf composition (% dry wt)[z]					
	P			K		
Treatment	Feb. 7	Mar. 27	Apr. 22	Feb. 7	Mar. 27	Apr. 22
N & K applied with trickle irrigation						
0%	0.37	0.25	0.29a	2.16b	1.92b	2.02
50%	0.37	0.25	0.25b	2.35a	2.24a	2.10
100%	0.36	0.26	0.25b	2.27a	2.31a	2.13
Frequency by trickle						
None	0.37	0.25	0.29a	2.16b	1.92b	2.02
Daily	0.37	0.26	0.25b	2.28a	2.33a	2.10
Weekly	0.36	0.25	0.26b	2.33a	2.21a	2.13
Irrigation method						
Trickle	0.37a	0.25	0.26	2.28a	2.20	2.10a
Overhead	0.35ab	0.26	0.25	2.08b	2.21	1.90b
Check	0.33b	0.26	0.27	2.16b	2.14	1.89b

[z]Mean separation within columns by Duncan's multiple range test, 5% level.

Soil values for total soluble salts, NO_3-N and K were consistently lower throughout the 1974-75 fruiting season with trickle irrigation than either overhead or non-irrigated treatments (Table 4). With the overhead irrigation treatments, these values were generally lower than with the check treatment. With the overhead and non-irrigated treatments, soil moisture levels commonly fell to the 5.5% to 3.5% level (−2 to −15 bars) during periods of low rainfall (8). Since soluble salt values were all standardized to 10% soil moisture (−0.06 bar), actual soluble salt values in the root zone were 2 to 3 fold over those shown in Table 4. Soluble salt values that exceed 2.3 to 2.5 mmhos/cm of conductivity in saturated extracts (about 2650 to 2900 ppm at 10% soil moisture) have been reported to reduce yields by 50% (5, 11). Soluble salt values with all trickle irrigation treatments were below this toxic level. Application of trickle irrigation without N and K resulted in total soluble salts, NO_3-N and K values that were significantly lower than where 50 or 100% of the N and K were applied either daily or weekly with the trickle irrigation. Soil P values were not influenced significantly by treatment.

Leaf N concn sampled at 3 times during the production season were not influenced by treatment. The N values with all treatments exceeded 3.1% at the earliest sampling and 3.5% at the later sampling. These values apparently were above the critical level for strawberries (1, 9). The P content of leaves was slightly higher at the early sampling for the trickle irrigated plant compared to those with overhead or no irrigation (Table 5). At later samplings, P leaf content was not influenced by irrigation methods. The K leaf content was influenced by irrigation method, rate, and method of fertilizer application. Leaf K values were highest with trickle and lowest with non-irrigated treatments. With trickle irrigation, increased K levels were obtained only where K was applied with the irrigation water. The amount (50 or 100% of the K) or timing of application (daily or weekly), had no influence on leaf K content. Without the application of supplemental K, leaf tissue levels fell below 2% but remained above the critical K range of 1.5% (1, 9).

In this study, strawberry yields were not increased with trickle irrigation above those with overhead irrigation when all the fertilizer was applied preplanting. These data indicate, that for maximum efficiency of trickle irrigation, N and K must be applied with the irrigation water. All fertilizer applied preplant or all with the trickle irrigation resulted in lower yields. Yields were similar where the fertilizer was applied daily or weekly so that frequency appears to be less important than the amount applied. Maximum yields in both seasons were produced with 135-78-149 kg/ha of N-P-K. Application of 50% of the N and K with the trickle irrigation over a 25-week period resulted in an application of approximately 2.7-0-3 kg/ha N-P-K/week. Water rates with trickle (34, 48, and 65% of the water applied with overhead) apparently were not critical for fruit production.

In both seasons, crop water requirements were not fully met by rainfall. Application of water by overhead irrigation increased yields by 43% and 22% during the two seasons, respectively, over those without irrigation. Application of water and 50% of the N and K by trickle irrigation resulted in yield increases of 69 and 48% over the check during the two seasons, respectively, with 1/3 to 2/3 as much water than that used for overhead irrigation. Similar water savings with trickle irrigation have been reported for pepper (4) and tomato (7).

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