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EFFECTS OF TRICKLE IRRIGATION AND FERTIGATION ON FRUIT PRODUCTION AND JUICE QUALITY OF 'VALENCIA' ORANGE

R. C. J. Koo
University of Florida,
Institute of Food and Agricultural Sciences,
Citrus Research and Education Center,
700 Experiment Station Road,
Lake Alfred, FL 33850

A. G. Smajstrla
University of Florida,
Institute of Food and Agricultural Sciences,
Agricultural Engineering Department,
Gainesville, FL 32611

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Abstract. **Fruit production and juice quality were measured during a 5-yr study of trickle irrigation. Irrigation treatments included no irrigation control, 2 or 4 drippers and 1 or 2 spray jets per tree. Fertilization treatments included dry fertilizer, 15 and 30% of the N and K supplied through the irrigation systems (fertigation). Irrigation increased fruit production 39 to 64% over the no irrigation control. Fruit production increase varied directly with increase in ground coverage by the irrigation treatments. Irrigation and partial fertigation treatments reduced both soluble solids (Brix) and acid concentration in juice. Partial fertigation treatments had minimal influence on fruit production.**

Trickle or low volume irrigation is gaining acceptance as the most popular method of irrigation for Florida citrus, because the systems are relatively low in cost and offer potential savings in water and energy by irrigating only a portion of the root system. Fertigation, applying fertilizer materials through the irrigation system is one of the potential advantages offered by trickle irrigation (3, 4, 8). Also there is the possibility of obtaining freeze protection from under tree spray-jet systems (1, 2, 7). It has been shown that citrus fruit production on sandy soils is increased by the ground surface area covered by trickle irrigation (5).

This study was initiated in 1978 to evaluate different surface area covered and rates of trickle irrigation on tree response. Partial fertigation treatments were also compared with dry fertilization. This paper summarizes the data of leaf analysis, fruit production and fruit quality over the 5-yr period.

Materials and Methods

The study was conducted on mature 'Valencia' orange [*Citrus sinensis* (L.) Osbeck] trees on rough lemon rootstock (*Citrus jambhiri* Lush) in central Florida. The soil was Astatula fine sand, a hyperthermic, uncoated Typic Quartzipsamments. The trees were planted in 1952 at a spacing of 15 ft within row and 30 ft between rows making a total of 97 trees per acre. Treatments involved both irrigation and fertigation. Irrigation treatments included comparisons of two drippers (D-2), 4-drippers (D-4) and one jet (J-1) and two jets (J-2) per tree at two rates of irrigation. Fertigation treatments involved supplying 15 and 30% of nitrogen (N) and potassium (K) in liquid form through the irrigation systems and the remainder in dry form. These treatments were compared to the dry fertilizer practice which was applied twice a year. All treatments were fertilized at rates equivalent to 180 lb. of nitrogen and 145 lb. of potassium per acre per year.

Irrigation and fertigation treatments were arranged in a 4x2x3 factorial design and replicated 4 times in single tree plots for a total 96 plots. A no-irrigation control was included as one of the treatments. Experimental design, coverage and water usage were discussed more fully in an accompanying paper (10).

Treatments were initiated in 1978. The freezes of 1981 and 1982 severely damaged the fruit but did only minor damage to the trees. Fruit production data were collected at the time of harvest and fruit samples were collected 1 to 2 weeks prior to fruit harvest to measure the juice quality. Fruit production data of 1981 and 1982 included both fruit on the tree and on the ground. Leaf samples of 5-month-old spring flush leaves from nonfruiting twigs were collected and analyzed for N and K.

All data were analyzed each year by analysis of variance. Only the 5-yr average of the main effects are presented, except where significant yearly trends and interactions are involved as in leaf N and K and fruit production.

Results and Discussion

Leaf N and K concentrations. The N and K concentrations of leaves were used to evaluate the treatment effects of irrigation and fertigation (Table 1). Although differences due to irrigation treatments were observed in both leaf N and K concentrations in 4 of the 5 yr but the trends were inconsistent from year to year. Leaf N concentration increased with area of irrigation water coverage in 1978 and 1979 but the trends were reversed in 1981 and 1982. Leaf K concentration showed both increase and decrease due to increased water coverage by the different irrigation treatments. Irrigation rates had no influence on leaf N and K concentrations indicating both the high and low rates are in the sufficient range.

Partial fertigation by supplying 15 and 30% of the N and K requirements resulted in lower leaf N concentration than the dry fertilizer treatment in 1978 and 1979 but the trend reversed in 1981 and 1982. Reasons for the reversal in trends are not clear. Leaf K concentration showed a slight but consistent increase with partial fertigation. The data were significant 3 of 5 yr. Data from this study were not as consistent as data from investigations where complete fertigation treatments were compared to dry fertilizer treatments (3, 4). In these studies (3, 4) greater coverage by fertigation produced higher leaf N and fruit production.

Fruit quality and production. Both soluble solids and acid concentration decreased with increase in ground coverage and irrigation rates (Table 2). These trends were consistent with results from earlier studies (6, 9). Partial fertigation treatments lowered the soluble solids concentration of the juice, which contrasted with previous results found in comparing complete fertigation with dry fertilization (3, 4). This should be further investigated.

Irrigation treatments increased fruit production over no irrigation control from 39 to 64% over the 5-yr period (Table 3). Increase in yield of soluble solids from the same treatments varied from 36 to 56% during the same period. The smaller increase in the yield of soluble solids was due to the dilution effects water has on juice solids (Table 2).

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Table 1. Main effects of irrigation and fertilization on N and K contents of 'Valencia' orange leaves.

Treatment	Nitrogen (%)					Potassium (%)				
	1978	79	80	81	82	1978	79	80	81	82
No irrigation[z]	2.32	2.61	2.73	2.53	2.80	1.29	1.36	1.70	1.91	1.87
Irrig. systems										
2 dripper	2.39	2.62	2.81	2.66	2.67	1.40	1.14	1.73	1.65	1.86
4 dripper	2.45	2.67	2.82	2.68	2.67	1.28	1.15	1.74	1.60	1.79
1 jet	2.42	2.59	2.76	2.57	2.67	1.14	1.17	1.72	1.87	1.77
2 jet	2.61	2.67	2.69	2.59	2.71	1.20	1.41	1.71	1.83	1.86
Significance[y]	**	*	*	**	ns	**	**	ns	**	**
Irrig. rate										
High	2.49	2.62	2.77	2.66	2.70	1.36	1.20	1.73	1.74	1.81
Low	2.45	2.65	2.77	2.59	2.66	1.16	1.24	1.72	1.74	1.83
Significance[y]	ns	ns	ns	**	ns	**	ns	ns	ns	ns
Fertilizer										
Dry	2.50	2.71	2.77	2.54	2.62	1.22	1.23	1.69	1.72	1.77
15% liq.[x]	2.49	2.61	2.76	2.68	2.76	1.30	1.17	1.74	1.74	1.85
30% liq.[x]	2.43	2.59	2.77	2.65	2.66	1.25	1.25	1.74	1.75	1.84
Significance[y]	*	**	ns	**	**	ns	*	*	ns	**

[z]Data from no irrigation control were not included in the statistical analysis.
[y]Statistical symbols—ns = not significant, * = significant at $P \leq 0.05$, ** = significant at $P \leq 0.01$.
[x]Fifteen or 30% of the N and K were applied through the irrigation system.

Fruit production increased with the area of coverage by the different irrigation treatments. The 2 drippers per tree treatment covered less ground surface area and produced less fruit than the 2 spray jets per tree treatment. The data were significant in 4 of the 5 crop years. No difference in fruit production was found among the irrigation treatments in 1979-80 when the annual rainfall was 13 inches higher than the long-term average (Table 3).

No difference in fruit production was found due to irrigation rates or partial fertigation treatments. This would indicate sufficient water was being supplied by the low irrigation rate and added water did not further increase fruit production. The study also showed it was possible to supply a portion of the nitrogen and potash through liquid fertigation. The data did not show any advantage or disadvantage from partial fertigation in tree response when compared to conventional dry fertilization.

Table 2. Main effects of irrigation and fertigation on juice quality and fruit weight of 'Valencia' orange.

Treatment	Juice quality					Fruit weight
	Content (%)	Brix (%)	Acid (%)	Ratio	Solids (lb/box)	(oz/fruit)
No irrigation[z]	53.3	12.3	0.96	13.0	6.28	6.7
Irrig. system						
2 dripper	53.9	12.0	0.95	12.7	6.13	7.3
4 dripper	54.9	12.2	0.98	12.7	6.35	6.8
1 jet	54.5	11.8	0.91	13.0	6.07	7.1
2 jet	54.1	11.6	0.90	13.0	5.93	7.0
Sig. (yr/yr)[y]	1/5	5/5	4/5	1/5	5/5	2/5
Irrig. rate						
Low	54.6	11.9	0.94	12.9	6.16	7.0
High	54.0	11.9	0.93	12.9	6.07	7.0
Sig. (yr/yr)[y]	1/5	2/5	2/5	0/5	4/5	1/5
Fertilizer						
Dry	54.3	12.1	0.94	13.1	6.22	7.0
15% liq.[x]	54.3	11.9	0.93	12.7	6.10	7.0
30% liq.[x]	54.4	11.8	0.93	12.8	6.04	7.2
Sig. (yr/yr)[y]	2/5	4/5	0/5	1/5	3/5	1/5

[z]Data from no irrigation control were not included in the statistical analysis.
[y]No. of years data showed significant difference at $P \leq 0.05$/no. of years data collected.
[x]Fifteen or 30% of the N and K were applied through the irrigation system.

Table 3. Main effects of irrigation and fertigation on fruit production and yield of solids of 'Valencia' orange.

Treatment	Fruit production (boxes/acre)					5-yr avg.	
	1978-79	79-80	80-81	81-82	82-83	Fruit	Solids
	Boxes/acre					(boxes/acre)	(lb./acre)
No irrigation[z]	345	320	172	297	369	301	1884
Irrig. system							
2 dripper	377	504	261	468	475	418	2567
4 dripper	400	466	315	468	494	429	26.59
1 jet	444	527	341	517	545	475	2894
2 jet	479	516	341	542	594	494	2934
Significance[y]	**	ns	*	**	*	**	**
Irrig. rate							
Low	429	575	320	479	528	454	2798
High	421	493	309	495	526	449	2729
Significance[y]	ns	ns	ns	ns	ns	ns	ns
Fertilizer							
Dry	430	505	343	479	568	465	2888
15% liq.[x]	421	504	316	472	509	444	2720
30% liq.[x]	425	501	285	509	502	444	2683
Significance[y]	ns	ns	ns	ns	ns	ns	ns
Rainfall (inches)	47.7	64.4	42.9	39.9	56.7		

[z]Data from no irrigation control were not included in the statistical analysis.
[y]Statistical symbols—ns = not significant, * = significant at $P \leq 0.05$ and ** = significant at $P \leq 0.01$.
[x]Fifteen or 30% of the N and K were applied through the irrigation system.

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