FERTILIZATION AND IRRIGATION EFFECTS ON FRUIT QUALITY

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Both fertilization and irrigation play important roles in fruit production and fruit quality. Nitrogen and potassium are the two principal nutrient elements used in citrus fertilization. Nitrogen affects both fruit production and fruit quality more than other nutrient elements. The influence of potassium on fruit production and fruit quality is not as apparent as that of nitrogen but it plays an important role. More investigations have been reported on these two elements than other nutrient elements in citrus literature. Other macronutrient and most micronutrient elements do not play a significant role in fruit quality except when the element in question is severely deficient.

Irrigation is practiced to promote tree growth and increase fruit production Its effect on fruit quality is mostly negative. Irrigation contributes to the efficiency of the fertility program.

Trends in fruit quality response to fertilization and irrigation are summarized in Table 1. Tables 2 to 5 are data to illustrate how different fertilizer elements and irrigation affect fruit quality measurements.

FERTILIZER ELEMENTS ON FRUIT QUALITY

Nitrogen: Increasing rates of nitrogen application will result in:

A. Juice Quality:

1. increase in juice, soluble solids, acid contents and juice color intensity
2. increase soluble solids per box
3. increase soluble solids per acre up to a certain point. Excessive nitrogen will lower the fruit production and lower the yields of soluble solids per acre.

B. External Fruit Quality:

1. decrease in fruit size and weight
2. increase in percent of green fruit at harvest
3. increase peel thickness
4. decrease the incidence of wind scar, russet and plugging in peel blemishes
5. increase the incidence of creasing and scab

C. Storage Decay: a reduction in the incidence of stem-end rot and green mold. Nitrogen has no effects on sour rot.

Table 1. Effects of mineral nutrition and irrigation on fruit quality.

Measurements	Macronutrient element					Micronutrient element					Irrigation
	N	P	K	Ca	Mg	Mn	Zn	Cu	Fe	B	
Juice Quality											
juice content	+	0		0	0	0	0	0	0	0	
soluble solids	+	0		0	+	0	0	0	+	0	
acid	+		+	0	0	0	0	0	0	0	
SS/A ratio		+		0	+	0	0	0	0	0	+
juice color											
red	+	0		?	?	?	?	?	?	?	0
yellow	+	0	-	?	?	?	?	?	?	?	+
solids/box	+	0		0	+	0	0	0	+	0	
solids/acre	+	+	+	0	+	0	0	0	0	0	+
External Fruit Quality											
size	-	0	+	0	+	0	0	0	0	0	+
weight	-	0	+	0	+	0	0	0	0	0	+
green fruit	+	+	+	0	0	0	0	0	+	0	+
peel thickness	+		+	0		0	0	0	0	0	
peel blemishes											
windscar	-	+	0	?	?	?	?	?	?	?	+
russet	-		0	?	0	0	0	0	0	0	0
creasing	+	0		?	?	?	?	?	?	?	0
plugging	-	0		?	?	?	?	?	?	?	
scab	+	0	0	?	?	?	?	?	?	?	+
Storage Decay											
stem-end rot		0		?	?	?	?	?		?	
green mold		0	0	?	?	?	?	?	?	?	+
sour rot	0	0	0	?	?	?	?	?	?	?	0

Increase (+) Decrease (-) No change (0) No information ?)

Phosphorus: High rates of phosphorus application will result in:

A. Juice Quality: lower the acid content which will give higher soluble solids-acid ratio. Phosphorus rates have no effect on soluble solids per box but may increase the soluble solids per acre due to increase in fruit production in soils that are low in phosphorus.

B. External Fruit Quality: increase the percent of green fruit and decrease in peel thickness. Phosphorus will increase the incidence of wind scar but reduce the incidence of russet fruit.

C. Storage Decay: storage decay is not affected by phosphorus application.

Potassium: High rates of potash application will result in:

A. Juice Quality: lower juice quality. Potassium applications produce mostly negative effects on juice quality except soluble solids per acre. Potash fertilization will increase fruit production and thus produce more soluble solids per acre.

B. External Fruit Quality:

1. increase fruit size and weight

2. more green fruit at harvest

3. increase in peel thickness

4. reduced incidence of creasing and plugging. Potash fertilization has no effect on wind scar, russet or scab.

C. Storage Decay: reduced incidence of stem-end rot

Calcium: Calcium has little or no effects on juice quality and most of the external fruit quality characteristics. No information is available on peel blemish or storage decay.

Magnesium: The effects of magnesium on fruit quality is negligible except in severe deficiency. High rates of magnesium application will result in:

A. Juice Quality: slight increase in soluble solids, soluble solids-acid ratio, soluble solids per box and soluble solids per acre.

B. External Fruit Quality and Storage Decay: slight increase in fruit size, fruit weight and a decrease in peel thickness. No information is available on other fruit quality characteristics.

Micronutrient Elements: There is not much information in the literature on the effects of micronutrient elements on fruit quality. Data that are available indicate most micronutrient elements do not affect fruit quality. Iron will increase the soluble solids content of juice and result in higher soluble solids per box. However, no difference in soluble solids per acre was found when fruit production was taken into consideration.

Table 2. Effects of rates of nitrogen and potash on fruit quality (Valencia).

Measurements	Nitrogen (lb/A/yr) 70	140	210	280	Sig. (yr/yr)[z]	Potash (lb/A/yr) 70	140	210	280	Sig. (yr/yr)[z]
Juice Quality										
juice content (%)	58.6	59.2	59.2	59.6	4/5	59.5	59.3	59.2	58.7	1/5
soluble solids (%)	11.3	11.7	11.9	12.4	5/5	12.0	11.9	11.8	11.6	3/5
acid (%)	0.71	0.75	0.78	0.80	5/5	0.76	0.79	0.83	0.83	4/5
SS/A ratio	16.0	15.7	15.3	15.4	0/5	15.6	14.9	14.6	14.6	5/5
solids/box (lb)	5.86	5.98	6.05	6.23	5/5	6.46	6.34	6.28	6.15	2/5
solids/acre (lb)	1573	2614	2772	2682	5/5	2047	2314	2147	2079	3/5
color: red	45.3	45.9	46.3	46.1	1/3	45.7	45.8	45.7	46.2	0/3
yellow	76.7	78.1	78.7	78.1	3/3	78.7	78.1	77.8	77.3	2/3
External Fruit Quality										
size (diam. cm)	7.95	7.85	7.87	7.72	4/5	7.62	7.85	7.90	8.00	5/5
weight (gram)	242	231	228	215	5/5	209	231	235	242	5/5
green fruit (%)	18.3	31.8	32.8	30.8	5/5	26.6	27.0	29.3	28.7	
peel blemishes										
windscar (%)	17.9	12.2	10.5	11.5	3/4	12.2	12.9	13.8	13.1	0/4
russet (%)	11.5	5.0	3.5	4.4	5/5	6.0	6.0	6.6	5.6	0/5
creasing (%)	0.08	0.35	0.39	0.73	3/4	1.08	0.22	0.14	0.11	4/4
plugging (%)	0.70	0.58	0.35	0.50	2/3	0.90	0.59	0.35	0.35	2/3
Storage Decay										
stem-end rot (%)	4.9	3.2	3.2	3.0	4/4	4.7	3.5	3.5	3.2	2/4
green mold (%)	3.2	2.3	1.9	2.7	2/4	3.0	2.3	2.1	3.1	1/4
sour rot (%)	0.4	0.4	0.3	0.3	0/4	0.4	0.3	0.3	0.4	0/4

[z](yr/yr) No. of yr showed significant difference over number of yr measured.

IRRIGATION ON FRUIT QUALITY

Overly frequent irrigation will adversely affect most fruit quality characteristics. Adequate irrigation will result in:

A. Juice Quality:

1. higher juice content, soluble solids-acid ratio

2. lower soluble solids and acid contents. Soluble solids per box will decrease but soluble solids per acre will increase because of increased fruit production from irrigation.

B. External Fruit Quality: irrigation will increase fruit size, weight and produce more green fruit. It will decrease the rind thickness. Among the peel blemishes, irrigation increases the incidence of windscar and scab, but reduces plugging. It has no effect on russet and creasing.

C. Storage Decay: irrigation will reduce the incidence of stem-end rot but it will increase the incidence of green mold. It has no effect on sour rot.

Summary

Nitrogen is the dominant nutrient element that affects fruit quality. Other nutrients and irrigation have lesser effects except under certain conditions. Increased nitrogen rates will result in smaller fruit size, lower incidence of wind scar, russet, plugging and stem-end rot. High nitrogen rates will produce more green fruit, more creasing and more intense juice color. High nitrogen rates will also produce fruit of higher soluble solids per box and per acre but the increase in soluble solids per acre is not proportional to the increase in soluble solids per box because excessive nitrogen will cause a decrease in fruit production. It seems a range of 150 to 250 pounds of nitrogen per acre per year would be desirable for most citrus varieties with fruit produced for fresh market using the lower end and processed fruit using the high end of the range.

Increased potassium rates will produce larger sized fruit and more green fruit at harvest. Higher potassium rates will reduce the incidence of creasing, plugging, stem-end rot and juice color intensity. A potash rate of 150 to 250 pounds per acre per year is sufficient for most citrus varieties. A balanced program of nitrogen and potassium rates is important to maintain good fruit production of high quality fruit. This is especially true for groves under high fertility program. A number of fruit disorders can be attributed to the imbalance of nitrogen and potassium programs.

Effects of irrigation on fruit quality is mostly negative. Therefore, increased fruit production and yield of soluble solids should be prime considerations in determining the frequency of irrigation. Irrigation will lower the soluble solids and acid contents of juice and increase the soluble solids acid ratio. The increased ratio obtained by irrigation can be used to hasten the maturity of oranges, mandarins, lemons and limes for fresh fruit market early in the season which will command a premium price.

Most successful groves in Florida are under a program of good fertilization and sound water management.

Table 3. Effects of irrigation (Valencia) and phosphorus (Temple) on fruit quality.

Measurements	Irrigation			Sig. (yr/yr)	Phosphorus		Sig. (yr/yr)[z]
	NI	Low	High		-P	+P	
Juice Quality							
juice content (%)	58.1	58.1	57.8	2/5	63.5	63.4	1/6
soluble solids (%)	12.3	12.3	11.7	5/5	13.4	13.1	3/6
acid (%)	0.91	0.90	0.81	5/5	1.21	1.10	5/6
SS/A ratio	13.7	13.8	14.4	4/5	11.2	12.0	5/6
solids/box (lb)	5.84	5.67	5.23	3/4	7.66	7.47	0/6
solids/acre (lb)	1653	2162	2329	4/4	7.83	889	2/6
color: red	45.9	45.9	45.6	1/4	45.4	44.8	1/3
yellow	78.2	78.2	78.7	1/4	79.7	78.5	1/3
External Fruit Quality							
size (diam. cm)	7.80	7.82	7.95	3/4	7.37	7.37	0/6
weight (gram)	232	235	237	3/5	194	190	2/6
green fruit (%)	11.5	11.7	21.4	4/5	10.7	13.2	2/4
peel blemishes							
windscar (%)	19.6	20.2	22.1	4/6	1.65	2.00	1/3
russet (%)	6.3	5.9	4.1	4/4	23.5	17.1	1/3
creasing (%)	0.12	0.11	0.13	3/4	0.67	0.65	1/5
plugging (%)	1.0	0.9	0.5	3/5	0.52	0.62	0/2
Storage Decay							
stem-end rot (%)	8.8	8.6	7.3	0/2	4.2	3.6	1/6
green mold (%)	1.1	1.6	1.8	1/2	17.6	15.7	2/6
sour rot (%)	0.3	0.4	0.3	0/2	1.9	2.1	0/6

[z](yr/yr) No. of yr showed significant difference over number of yr measured.

Table 4. Effects of micronutrients on juice quality and solids (Pineapple)

Element	Juice content	Soluble solids	Acid	SS/A ratio	Soluble solids Box	Soluble solids Acre
	%	%	%		lb	lb
+ Manganese	56.8	10.9	0.74	14.7	5.57	1326
- Managaese	57.9	11.1	0.77	15.0	5.78	1214
+ Zinc	57.4	10.9	0.76	14.3	5.63	1103
- Zinc	57.8	11.1	0.77	14.4	5.77	1559
+ Copper	57.4	10.9	0.76	14.3	5.63	1103
- Copper	57.4	11.1	0.77	14.4	5.70	1117
+ Boron	57.4	10.9	0.76	14.3	5.63	1103
- Boron	56.6	11.0	0.77	14.3	5.60	1058
+ Iron	57.2	11.8	0.78	15.1	6.07	807
- Iron	56.2	11.1	0.76	14.6	5.61	825

Table 5. Effects of micronutrients on external fruit quality (Pineapple).

Element	Fruit weight	Fruit size	Green fruit	Peel thickness
	g	cm	%	mm
+ Manganese	188	7.3	26.7	3.8
- Manganese	190	7.3	23.7	3.7
+ Zinc	185	7.3	25.4	3.7
- Zinc	194	7.3	22.7	3.9
+ Copper	185	7.3	25.4	3.7
- Copper	194	7.2	16.2	4.0
+ Boron	185	7.3	25.4	3.7
- Boron	195	7.2	19.8	3.9
+ Iron	178	7.2	13.1	3.8
- Iron	180	7.2	21.3	3.9

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