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EFFECTS OF LOCATION, CULTIVAR, IRRIGATION, AND TEMPERATURE ON WATERSOAKING AND SEED QUALITY IN WATERMELON FRUIT[1]

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Abstract. **Watermelons** [Citrullus lanatus **(Thunb.) Matsum and Nakai] were grown at Leesburg and Gainesville to evaluate the effect of environmental factors on fruit watersoaking and on seed quality. Watersoaking was related to cultivar and was enhanced by irrigation. Watersoaking in fruit of 'Charleston Gray' at both locations was negligible, but 'Smokylee' developed 34% watersoaking at Leesburg and 83% at Gainesville. An increase in the water rate from 1 to 5 inch/week at Leesburg increased the occurrence from 45% to 80% in fruit at the second harvest. At Gainesville, an increase in irrigation rate from 0 to 1 or 5 inches/ week significantly increased the watersoaking occurrence from about 70 to 90%. No significant correlation was found between watersoaking severity and fruit maturity from the pink to over-mature stage. Shading fruit in the field during development reduced the surface temperature by 30°F over non-shaded fruit but did not affect watersoaking. Seed germinations from fruit randomly selected at the last harvest was lower at Leesburg (66%) than at Gainesville (83%). Shading fruit led to a reducation in germination at Leesburg.**

'Smokylee', a recently released watermelon *(Citrullus lanatus)* cultivar (2) contains high sugar levels and is among the most resistant to Fusarium wilt. However, wide-spread production of this cultivar has not occurred due to poor seed germination, fruit sun-burning, white seed, and an internal watersoaking. This internal disorder resembles bruising and was assumed to occur in handling and in transit. During 1974, however, this abnormality was observed in watermelons cut in a field at Live Oak. Although watersoaking has been widespread in some fields it has not been found in most fields.

Studies reported here were conducted to evaluate the effect of location, cultivar, shade, stage of maturity at harvest, and storage on the occurrence of watersoaking and seed germination in watermelon.

Experimental Procedure

Experiments were conducted with 'Charleston Gray' and 'Smokylee' watermelons at Leesburg on Apopka sand and at Gainesville on Myakka fine sand during 1975. Treatments were arranged in a split-split-plot experiment. At Leesburg, main plots were (a) 1 inch/week, and (b) 5 inches/week from rainfall and overhead irrigation. At Gainesville, main plots were supplemental overhead irrigation rates as follows: (a) none, (b) 1 inch/week, and (c) 5 inches/week. Differential irrigation rates were applied after first fruit set. Subplots were cultivar and sub-sub-plot treatments were (a) shaded fruit and (b) non-shaded fruit. Sub-sub-plots were 50 x 110 feet and were replicated 3 time at Leesburg and were 9 x 100 feet with 4 replications at Gainesville. Treatments were arranged in randomized block designs. Watermelon seed were planted at Leesburg on February 26, 1975, and at Gainesville on March 19, 1975, and were fertilized and grown as previously described (3). For the shaded treatment, 18 fruit with a length of approximately 4 inches were covered with a 1 x 2 foot piece of tin.

Four to 6 fruit were selected for harvest from each treatment in each of 3 maturity categories to approximate pink, pale red, and red flesh colors. Two or 3 fruit in each category were cut and evaluated on the days of harvest (May 22 and June 11 at Leesburg and June 24 and July 3 at Gainesville). The remaining fruit were stored at 70 to 90°F before evaluations on June 6 and 20 at Leesburg and on July 2 and 11 at Gainesville. Flesh maturity was visually rated on a scale as follows: (1) pink, (2) pale red, (3) good red, (4) dark red, and (5) orange or over-mature. Watersoaking was visually rated as follows: (1) none, (2) slight, (3) moderate, (4) severe, and (5) very severe. The rind was removed from a center 0.5 inch slice of fruit and the juice was extracted with a ricer. Soluble solids level of the juice was measured with a hand refractometer. Flesh firmness was measured on the stem half of the fruit as previously described (4). Data were subjected to analysis of variance. Fruit surface and flesh temperatures 2 and 4 inches below the surface were measured by means of thermocouples at Leesburg and Gainesville. Thermocouples were taped onto the surface of randomly selected fruit. Temperatures were recorded at 15 minute intervals. At the last harvest, 3 fruit were sampled from each irrigation and shade treatment for seed germination determinations.

Results and Discussion

Watermelon fruit production at both Leesburg and Gainesville was excellent but was not significantly influenced by water rate (Table 1). Rainfall was fairly equally distributed throughout the 14-week growth period at Gainesville and averaged 1 inch/week. Weekly rainfall averages were 0.6 inch/week at Leesburg, but one-half of the seasons rainfall occurred in May. Early in the season, rainfall averaged less than 0.4 inch/week. Apparently, rainfall at Gainesville and the lower water rates at Leesburg were adequate for maximum production. Yields of 'Charleston Gray' and 'Smokylee' were statistically similar at both locations. Fruit of 'Smokylee' had significantly higher soluble solids than 'Charleston Gray'. Differences between cultivar in soluble solids were 1.0% at Leesburg and 0.8% at Gainesville (Table 1). Water rate did not significantly effect soluble solids. However, a trend for a reduction in soluble solids with an increase in water rate was noted at both locations.

The occurrence of watersoak flesh in fruit of 'Charleston Gray' was minimal at both locations and was less than 1% at Leesburg and 2% at Gainesville. Only 6 'Charleston Gray' fruit of 554 evaluated showed a slight occurrence of

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Table 1. Effect of irrigation rate and cultivar on watermelon yield and *soluble solids* (S.S.) at Leesburg and Gainesville.

Treatment	Marketable yield No./acre	Tons/acre	Lb/fruit	S.S. %
Irrigation inch/week			Leesburg	
1	2,308	18.0	20.7	9.3
5	2,173	17.5	21.3	8.9
F value[z]	N.S.	N.S.	N.S.	N.S.
Cultivar				
Charleston Gray	2,129	16.4	20.3	8.6
Smokylee	2,351	19.1	21.7	9.6
F value	N.S.	N.S.	N.S.	**
Irrigation inch/week			Gainesville	
0	1,257	14.7	23.2	9.1
1	1,390	16.3	23.5	8.8
5	1,141	13.1	22.9	8.6
F value	N.S.	N.S.	N.S.	N.S.
Cultivar				
Charleston Gray	1,260	15.1	23.9	8.4
Smokylee	1,266	14.3	22.5	9.2
F value	N.S.	N.S.	*	**

[z]F values were not significant (N.S.) and significant at the 5% (*) and 1% (**) levels.

watersoaking (rating 2). Watersoaking was considerably greater in 'Smokylee' at both locations. At the first harvest at Leesburg, 15% of the 'Smokylee' fruit showed watersoaked symptoms (Table 2), but the occurrence was not influenced by irrigation rate or shade. At the second harvest, the occurrence increased significantly from 45% to 80% with an increase in the irrigation rate from 1 to 5 inches/week. At Gainesville, about 85% of the fruit showed watersoaking at each harvest. In the non-irrigated treatments, over 70% of the fruit were watersoaked. Application of water at rates of 1 or 5 inches/week significantly increased the occurrence to 90% of the fruit. At the first harvest, shading the fruit increased watersoaking from 78% in non-shaded fruit to 91% in shaded fruit. In addition to a greater occurrence, the severity of watersoaking was also greater at Gainesville where 19% of the fruit were severely or very severely affected compared with 3% at Leesburg (Table 3). At both locations, fruit weight correlated significantly with the severity of watersoaking. Very severely affected fruit were smaller in size than fruit showing slight or moderate symptoms of watersoaking. The severity of watersoaking was not significantly correlated with fruit maturity, soluble solids, or firmness.

Table 2. Effects of irrigation rate and shade on the occurrence of watersoaking on 'Smokylee' fruit.

Treatment	Fruit harvest Leesburg 5/22	Leesburg 6/11	Gainesville 6/24	Gainesville 7/3
Irrigation inch/week		Watersoaked fruit, %		
0	—	—	75	70
1	15	45	93	95
5	15	80	85	90
F value[z]	N.S.	*	*	*
Shade	19	53	91	87
No shade	11	71	78	83
F value	N.S.	N.S.	*	N.S.

[z]F values were not significant (N.S.) or significant at the 5% (*) level. Differences between the 0 and the mean of the 1 and 5 inch/week rates were significant.

The amount of water applied had no significant influence on watersoak rating of 'Smokylee' fruit at Gainesville (Table 4). Watersoak severity tended to be lower at the 0 water rate. At Leesburg, watersoak ratings were significantly greater with the 5 inch/week water rate than with the 1 inch/week rate. Watersoak ratings increased from 1.3 to 1.7 with an increase in the irrigation rate. At both locations, the severity of watersoaking was significantly greater at the second harvest than the first harvest (Table 4). The mean watersoak rating for 'Smokylee' fruit at Leesburg averaged 1.1 at the first harvest and 1.9 at the second harvest. This

Table 3. Relationship between fruit weight, maturity, soluble solids, firmness, and rind thickness and severity and number of 'Smokylee' and 'Charleston Gray' fruit affected with watersoak.

Characteristic measured	'Smokylee' Watersoak rating[z] 1	2	3	4	5	r[y]	'Charleston Gray' Rating 1	2	3-5
					Leesburg				
Weight, lb	22.8	24.9	23.1	21.7	16.5	—.24*	22.6	26,0	
Maturity[x]	3.2	4.1	4.3	4.3	4.5	.13	3.6	4.0	
Soluble solids, %	9.5	9.8	9.6	9.7	9.2	—.13	8.6	9.5	
Firmness, lb	3.4	2.9	3.0	4.0	3.2	.15	4.0	4.3	
Rind thickness, mm	25	24	24	29	32	.22*	23	23	
Fruit, no.	204	73	24	6	2		288	1	0
%	66	23	8	2	1		99.7	0.3	0
					Gainesville				
Weight, lb	24.4	20.2	19.3	19.8	16.2	—.13*	21.0	21.0	
Maturity[x]	2.8	2.9	2.8	3.1	3.3	.12	3.0	3.0	
Soluble solids, %	9.6	9.2	9.3	9.1	8.9	—.03	8.5	8.1	
Firmness, lb	3.7	4.0	4.1	4.0	3.7	—.06	4.1	4.0	
Rind thickness, mm	28.0	27.0	28.0	29.0	26.0	—.01	25	25	
Fruit, no.	47	84	96	30	21		260	5	0
%	17	30	34	11	8		98	2	0

[z]Watersoak ratings were (1) none, (2) slight, (3) moderate, (4) severe, and (5) very severe.
[y]Correlation coefficient between characteristic and watersoak ratings were calculated with fruit having watersoaked ratings between 2 and 5 and were significant at the 5% (*) level.
[x]Maturity (flesh) was rated (1) pink, (2) pale red, (3) good red, (4) dark red, and (5) orange or over-mature.

increase in rating probably reflects the greater occurrence of watersoaking at the second harvest. At Gainesville, 'Smokylee' watersoak ratings averaged 2.5 at the first harvest and 2.7 at the second harvest. Storage of the fruit after harvest had little effect on the severity of watersoaking.

Table 4. Effect of irrigation rate, time of harvest, and storage on the watersoak severity of 'Smokylee' watermelon fruit at Leesburg and Gainesville.[z]

Irrigation inch/week	Harvest1 Storage[y] 1	2	Harvest2 Storage 1	2	Irrigation mean
			Leesburg		
1	1.1	1.1	1.5	1.5	1.3
5	1.1	1.2	2.6	1.9	1.7
Mean	1.1		1.9[w]		
F value[x]					*
			Gainesville		
0	2.2	2.7	2.2	2.3	2.3
1	2.7	2.6	3.2	2.7	2.8
5	2.3	2.7	3.1	2.6	2.7
Mean	2.5		2.7[w]		
F value					N.S.

[z]Ratings were from (1) none to (5) very severe.
[y]Fruit were evaluated (1) at harvest and (2) 8 to 15 days after harvest.
[x]F values for irrigation were significant at the 5% (*) level and not significant (N.S.).
[w]Differences between harvest dates were significant (*).

Shading the fruit during development had no significant influence on watersoak rating but did affect fruit temperatures. Fig. 1 shows data that were typical of temperatures recorded during several days at each *location. The fruit* surface of shaded fruit of both cultivars was as much as 30°F cooler than unshaded fruit. With non-shaded fruit, the surface of 'Smokylee' fruit warmed up slightly more rapidly during the day but the maximum temperature was not as high as with 'Charleston Gray'. The flesh of unshaded 'Smokylee' fruit attained a temperature 4 to 5°F higher than 'Charleston Gray' 2 inches below the fruit surface and 8°F 4 inches below the surface. During most of the night period, the flesh temperature of 'Smokylee' fruit was 2 to 3°F lower than that of 'Charleston Gray'.

The amount of irrigation water applied had no influence on the number of seed produced at either location and % germination (Table 5). At both locations, more seed were produced by non-shaded as compared to shaded fruit. However, this was probably due to fruit size since the number of seed produced/lb of fruit was the same for both treatments. Average germination percentages were lower at Leesburg (65%) than at Gainesville (83%). At Leesburg, shading the fruit led to a significant reduction in % germination.

Apparently, the watersoak disorder *is closely related to* cultivar and is enhanced by water rate. At the first harvest at Leesburg, when rainfall was low, the occurrence of watersoaking was also low. Later in the season when rainfall increased, and with the application of 5 inches/week irrigation, watersoaking also increased. The occurrence of watersoaking was higher at Gainesville where rainfall was greater

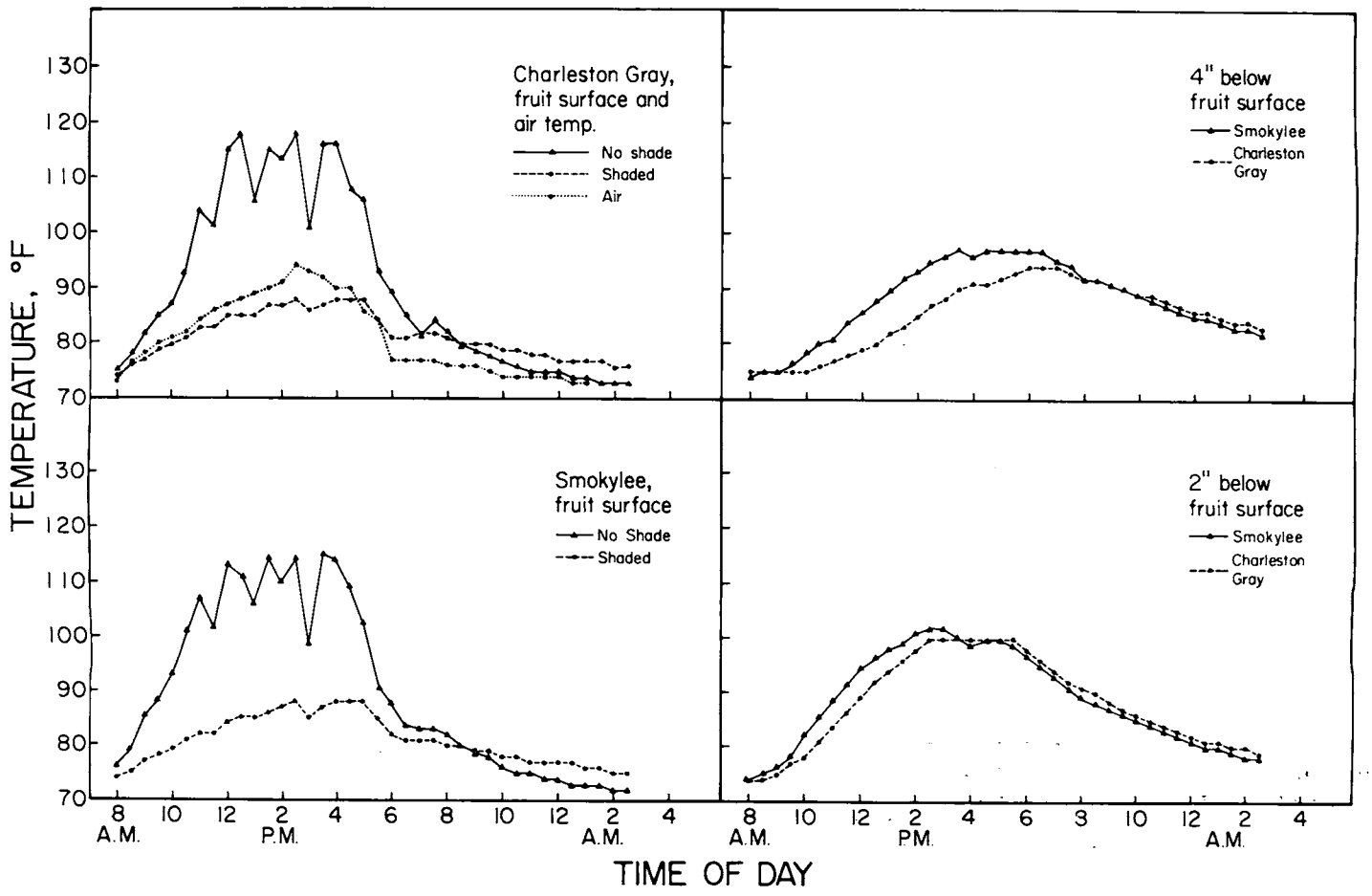

Fig. 1. Effects of cultivar and shade on temperature of watermelon fruit on May 31, 1975, at Leesburg.

Table 5. Effect of irrigation rate and fruit shading on seed in 'Smokylee' fruit.

Treatment	Seed/fruit, no. Mature	Seed/fruit, no. Immature	Germ %	Fruit wt, lb	Seed/lb of fruit, no. Mature	Seed/lb of fruit, no. Immature
Irrigation inch/week			Leesburg			
1	509.5	135.2	67	27.5		
5	549.7	110.1	65	28.8		
F value[z]	N.S.	N.S.	N.S.	N.S.		
Shade	455.8	74.0	45	27.1	17	3
No shade	603.3	171.3	87	29.3	20	6
F value	N.S.	*	*	N.S.		
Irrigation inch/week			Gainesville			
0	529.5	162.1	84	22.8		
1	506.2	159.3	81	24.0		
5	562.9	149.2	83	24.4		
F value	N.S.	N.S.	N.S.	N.S.		
Shade	393.8	119.2	81	16.54	24	7
No shade	672.0	194.6	84	30.96	22	6
F value	**	**	N.S.	**		

[z]F values were not significant (N.S.) at the 5% (*) and 1% L (**) levels.

than at Leesburg. At Gainesville, watersoaking was further increased by irrigation. The disorder can develop at a very early stage of fruit development. Watersoaking was found in pink, pale-red, and red fruit and probably increases as affected fruit matures. In this study, severely affected fruit tended to be more mature than those less affected. Even though 'Charleston Gray' fruit were consistently lower in soluble solids than 'Smokylee', no significant correlation between soluble solids and watersoak severity in 'Smokylee' was found. It is possible that soluble solids other than sugars are related to watersoaking. In apples, watercore (1), a disorder that resembles watersoaking in watermelons, is related to sorbitol (a polyhydric sugar alcohol) in the fruit (5). Although no consistent relation between shade and watersoaking was found, only temperatures in the fruit were reduced by shade.

This study indicates that poor seed quality and watersoaking in 'Smokylee' are enhanced by different factors. Watersoaking was more severe at Gainesville where rainfall was greater than at Leesburg. Seed germination was lower in fruit that developed under the dryer conditions at Leesburg.

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CHLORINATED HYDROCARBON RESIDUE IN SOILS, SPIDERS AND RATS OF THE HOLE-IN-THE-DONUT REGION AS INDICATORS OF ENVIRONMENTAL RESIDUES[1]

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Abstract. **Areas of the Hole-in-the-Donut region of the Everglades National Park have been used extensively for vegetable production. An opportunity became available to assess the present amount of chlorinated hydrocarbon residues in soils from several locations, those intensively farmed and those from nonfarmed areas. Some spiders and rodents collected from these locations were also analysed for chlorinated hydrocarbon content as a measure of the effect of long term pesticide usage. Results indicate that relatively low amounts of chlorinated hydrocarbon exist at the present time in the soils, even those used intensively in vegetable production. Spiders and rodents also contained low levels of chlorinated hydrocarbon residues.**

The Hole-in-the-Donut region of Everglades National Park has been an important vegetable production area in Florida for a number of years. Since insecticides were used in commercial practices, it seemed valuable to assess their persistence in the soil and in species which could be expected to accumulate them. The chlorinated hydrocarbon residues found are the subject of this report. Nutrient analy-

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