Table 2. Effect of spray treatments on yield and % marketable 'Irwin' mango fruit.

Treatment	Rate (g/liter)	Fruit (avg. no./plot)	Marketable fruit (%)
Benomyl	1.8	378 a[z]	98.1 a
Thiophanate methyl	1.8	400 a	99.0 a
Captafol	1.8	450 a	97.2 a
Mancozeb	1.8	380 a	95.4 a
Vinc.ozolin	1.8	345 a	98.3 a
Tribasic copper	3.6	433 a	41.9 b
Control	—	391 a	5.2 c

[z]Mean separation in columns by Duncan's multiple range test, 5% level. Single tree plots replicated 5 times.

Discussion

Excellent anthracnose control is provided by benomyl, and there is no indication that there is resistance to the toxicity of benomyl in the anthracnose fungus population. Reports of benomyl control failures with other pathogens are increasingly prevalent in the literature (1, 5, 16, 17). The new compound thiophanate methyl was as effective as benomyl. Both thiophanate methyl and benomyl break down to methyl 2-benzimidazole-carbamate (MBC) the fungitoxic derivative of the 2 chemicals (2, 6, 9, 10) which because of their similarity could result in the loss of both chemicals. The new form of captafol (Difolatan 80 Sprills) and vinclozolin show promise for anthracnose control.

At present the only 2 fungicides available to Florida mango growers are benomyl and copper (11). If benomyl is lost because of resistance in the anthracnose fungus, growers will have to rely on copper compounds that are only 50% as effective as benomyl and the new fungicide thiophanate methyl. The development of new fungicides and approval by the Environmental Protection Agency (EPA) are very much needed.

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Proc. Fla. State Hort. Soc. 97:345-347. 1984.

THE USE OF MUNICIPAL TREATED EFFLUENT FOR PEACH TREE IRRIGATION

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Additional index words. Prunus persica, mineral nutrition.

Abstract. **An experiment was conducted in Central Alabama using municipal treated effluent for irrigation of peach trees (**Prunus persica **(L.) Batsch 'Harvester') on a sandy loam soil. After 3 yr of applications, treated trees developed no symptoms of mineral element deficiencies or toxicities. Leaves from treated trees were visually greener than leaves from non-treated ones. Application of the treated effluent advanced flowering, fruit set, fruit maturity and ripening. Fruits from treated trees were softer, contained higher soluble solids, lower acidity and produced more ethylene than non-treated fruits. N, P, K, Fe, Mn and B were substantially higher in leaves sampled from treated trees than from the control.**

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In recent years, treated municipal wastewater has become an important potential source of irrigation, plant nutrients, and is being used successfully in the production of high yield of marketable quality crops (1, 7, 10, 13). Wastewater has been used to increase yield and improve quality of corn, rye (14, 20), sorghum (9), wheat grains (8), alfalfa and other crops (21, 26). The response of plants and soils to municipal treated effluent is dependent on the quality of the applied effluent and nature and efficiency of the wastewater treatment.

In spite of the successful use of treated municipal wastewater on many agronomic crops, little information is available on its use, or other wastewater, for irrigation of fruit crops (15, 19).

Most of Alabama fruit trees are grown on sandy soils which are low in natural fertility with low cation exchange capacity. Depending on their chemical contents, effluents from non-industrialized communities contain all the essential and functional elements required for normal growth and development of fruit trees (6, 27). Although fruit trees grow under a wide range of nutritional levels, they require all the essential and functional elements in order to maintain proper growth and high production of marketable quality fruit. Lack or excess of one or more of the essential elements will bring about deficiency symptoms or toxicity patterns on the leaves or other parts of the tree or the fruit. Therefore, tree growth and symptom expressions are functions of 2 variables of nutrition, namely the physiological availability and the balance between all nutrients (24). Applying effluent to fruit trees is expected to improve quality, increase yield, and reduce production costs.

The objectives of this research were to study the effects of municipal treated effluent on fruit quality and mineral element contents of peach trees growing under Alabama conditions.

Materials and Methods

Forty-four, 3-to 4-yr old peach trees (*Prunus persica* (L.) Batsch 'Harvester') planted on a sandy loam soil were used for this study in a randomized complete block design with 3 replications. Municipal treated effluent, brought from a local treatment facility in a 2000-liter tank, was applied to each tree. Application was made in a circular pattern 30 to 60 cm around the stem of each tree during the growing season. Application rate was 60 to 80 liters per tree every 2 weeks from February until August, depending on the environmental conditions. All trees received general cultural practices adapted to the location except for irrigation and fertilization. Control trees were watered with tap water at 60 to 80 liters per tree, and received complete fertilizer formulation (8-8-8) twice during the growing season. Irrigation and fertilization of treated trees were provided by municipal treated effluent.

During the growing season, flowering date, fruit set, growth rate and yield were recorded. Peach fruits were harvested at horticultural maturity and were used for quality evaluation. Fruit firmness was determined by the EFFE-GI fruit pressure tester with a 7.9 mm plunger. Fruits were cut and a combined sample of fresh wedges taken from all fruits per replicate were used for compositional analysis. Soluble solids content (SSC) was determined with Atagor refractometer, titratable acidity was determined by titrating 6 g of extracted juice to pH 8.1 with 0.1N NaOH. In a sample of 20 ml of filtered juice pH was determined using a Chemcadet pH meter. Ethylene evolution from peach fruits were determined after harvest using a Shimadzu gas chromatograph equipped with linear recorder. A composite sample of 30 leaves was collected monthly during the growing season for chlorophyll determination and mineral analysis. Chlorophyll was determined by the method of Basiouny et al. (5). N, P, K, Fe, Mn and B were determined by Kjeldahl analysis or atomic absorption spectrophotometry.

Results and Discussion

Plant morphology. The use of municipal treated sewage effluent as irrigation water enhanced the growth and development of peach trees. No symptoms of mineral element deficiency or toxicity have been detected on the leaves or stems of the experimental trees. These trees showed no signs of physiological disorders which might have developed from the use of the treated effluent. There were noticeable differences in size, rate of growth and the degree of greening between effluent-treated and control trees. Flower production was 4 to 7 days earlier and the fruit set was heavier and more regular in treated than non-treated trees. Fruits from treated trees were normal in size and color. Measurements of tagged fruit showed the typical double sigmoid growth curve. These fruits reached edible stage approximately 9 to 13 days earlier than fruits from control trees.

Effects of treated effluent on leaf mineral elements. Peach leaves accumulated significantly higher levels of N, P, Fe, and B, but not of K and Mn, as a result of the treated effluent application (Table 1, 2 and 3). These levels were 30.7, 43.8, 13.4 and 34.2% greater for N, P, Fe and B, respectively. Mature leaves sampled in March from the experimental trees were noticeably higher in mineral contents than leaves sampled at later dates. The higher mineral contents probably resulted from a greater demand for nitrogenous materials because trees bloom during this time.

Table 2. Effects of municipal treated effluent on Fe and Mn content of peach leaves.[z]

Sampling date	Fe Treated (ppm)	Fe Control (ppm)	Diff.	Mn Treated (ppm)	Mn Control (ppm)	Diff.
March	88	74	14*[y]	73	70	3
April	86	71	15*	74	66	8*
May	80	62	18*	69	64	5
June	77	70	7*	67	66	1
July	74	61	13*	59	53	6*
August	80	63	17*	62	60	2

[z]Average of 3 replications.
[y]Significant at the 5% level using the "t" test.

A fluctuation of leaf mineral contents during the growing season was noticeable which was related to the climatic conditions, fruit load and the different growth and developmental stages of the fruit. However, regardless of the monthly application of constant amount of the treated effluent to the experimental trees, leaf concentration of N, P, K, Fe, Mn and B showed a gradual decrease as the season progressed. This finding agrees with previous reports (2, 12, 22). This could be due to either a net movement from leaves or dilution associated with leaf expansion. High concentrations of P (43.8%) and B (34.9%) in leaf samples collected from treated trees reflected the exceptionally high level of

Table 1. Effects of municipal treated effluent on N, P, and K content of peach leaves.[z]

Sampling date	N Treated (%)	N Control (%)	N Diff.	P Treated (%)	P Control (%)	P Diff.	K Treated (%)	K Control (%)	K Diff.
March	3.6	3.0	0.6*[y]	0.25	0.18	0.07*	2.1	1.7	0.4
April	3.0	2.7	0.3	0.24	0.18	0.06*	2.0	1.6	0.4
May	3.3	2.3	1.0*	0.26	0.17	0.09*	2.0	1.3	0.7*
June	3.4	2.8	0.6*	0.20	0.13	0.07*	1.7	1.4	0.3
July	3.5	2.5	1.0*	0.33	0.14	0.19*	1.7	1.4	0.3
August	3.7	2.4	0.7*	0.23	0.16	0.07*	1.8	1.2	0.6*

[z]Average of 3 replications.
[y]Significant at 5% level using the "t" test.

Table 3. Effects of municipal treated effluent on B and total chlorophyll of peach leaves.[z]

Sampling date	B Treated (ppm)	B Control (ppm)	Diff.	Total Chlorophyll Treated (mg/g fresh wt.)	Total Chlorophyll Control (mg/g fresh wt.)	Diff.
March	53	42	11*y	2.67	2.01	0.66*
April	48	40	8*	2.49	2.11	0.38*
May	49	38	11*	2.63	2.14	0.49*
June	54	32	22*	2.71	2.23	0.48*
July	53	41	12*	2.72	2.25	0.47*
August	50	33	17*	2.61	2.28	0.33*

[z]Average of 3 replications.
[y]Significant at the 5% level using the "t" test.

these elements in treated municipal effluent. This could be due to the use of household bactericides and detergents. P. requirement of fruit trees is not as high as that of many field and some vegetable crops. Unlike B and some other elements, P is not excessively absorbed to the point of producing direct injury to fruit trees. The chief detrimental effects of high P are on the absorption and utilization of other metals such as Cu, Zn, and Fe. There have been many successful attempts to reduce P, as well as other element levels in treated effluents by chemical and biological methods (17, 18, 23), a matter which makes the use of such effluents safe for the irrigation of fruit trees.

Total chlorophyll. Chlorophyll content of leaves from effluent-treated trees sampled during the growing season were significantly higher than that of leaves from control trees (Table 3). This could be due to the significant increase in mineral element contents, particularly Fe and N, in treated leaves.

Effects of treated effluent on fruit quality. Application of treated effluent as irrigation water to peach trees significantly improved fruit quality (Table 4). Peach fruits sampled from treated trees at horticultural maturity were significantly softer with higher soluble solid content than fruits harvested from non-treated trees. There was 44.2% reduction in fruit firmness accompanied by 12% increase in SSC. Fruits harvested from treated trees were lower in titratable acidity (21.6%) and higher in pH (5%) than fruits from control trees. Firmness has long been used for fruit quality evaluation (4). Although not necessarily related to color or size of the fruit, firmness is associated with maturity (3). Levels of SSC and titratable acids are important in determining fruit flavor (11). Various workers have found that fertilizer application, particularly nitrogen, have variable effects on SSC of several fruits (25). Application of municipal treated effluent in this study substantially improved quality and enhanced maturity of peach fruit.

Soil application of treated effluent to peach trees stimulated ethylene production of the fruit. Fruit from treated trees produced 29.7% more ethylene than untreated fruits.

Table 4. Some characteristics of peach fruit treated with municipal treated effluent.[z]

Measurement	Treated	Control	Diff.
Firmness (Kg)	2.2	3.9	1.7*y
Soluble solids (%)	11.3	10.1	1.2*
Titratable acidity (%)	0.37	0.45	0.08*
pH	4.22	4.01	0.21*
Ethylene evolution (ul C_2H_4/kg/hr)	46.2	35.6	10.6*

[z]Average of 3 replications.
[y]Significant at the 5% level using the "t" test.

Ethylene production is considered a major parameter for ripening of many fruit (16). No direct relationship between soil application of treated effluent and ethylene production was established. However, the accelerating maturity and ripening processes brought about by the use of treated effluent were accompanied by higher ethylene production by fruits from treated trees. Early maturity of fruit nearly always results in economic gain to fruit growers.

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