that consumers tend to eat more sweet potatoes as they age.

The size of family variable again exhibited a large positive coefficient as expected. Each additional member of the family would increase weekly family consumption by almost .2 pound.

The spring shift variable coefficient was negative and significantly different from the fall base. The winter season shift coefficient was not significantly different than the fall base.

The same pattern in urbanization existed for non-white households as observed for white households. The urban and rural nonfarm households consumed significantly less sweet potatoes than the rural farm consumers.

The non-consuming households was of course significantly different from the consumption levels of consumers. The fact of the coefficients' significance is not as interesting as the fact that its absolute value closely approximated the constant value. Thus, the relationship would predict zero consumption levels for these households at mean values of the variables. This provides some evidence of the predictive power of the relationship.

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An Attempt to Overcome Iron-Induced Manganese Deficiency in 'July Elberta' Peach Trees with Manganese Chelate[1]

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Abstract. Disodium manganous ethylenediamine tetraacetate (MnEDTA), applied to the soil with 113 and 227 g sodium ferric ethylenediamine di-(o-hydroxyphenylacetate) (FeEDDHA), increased the concentration of Mn and reduced the concentration of Fe in 'July Elberta' peach leaves (*Prunus persica* (L) Batsch). Both rates of the Fe chelate increased Fe and reduced Mn and K in the leaves when compared to non-treated ones. Both rates of the Fe chelate reduced Fe chlorosis and increased shoot growth and size and yield of fruit. Mangenase chelate with 113 g Fe chelate reduced N in the leaves and increased trunk growth. Manganese chelate with 227 g Fe chelate reduced P in leaves. The Zn content in leaves, size of fruit, leaf chlorosis, trunk and shoot growth were not affected by Mn chelate applied with Fe chelate.

Shive et al (6, 9, 10) and Twyman (12, 13) reported that high Mn levels reduced Fe absorption from nutrient solutions, lowering water-soluble Fe levels in plant tissue. High Fe levels likewise depressed Mn absorption from nutrient solutions and reduced the level of water-soluble Mn in plant tissue, although to a much lesser degree than the effects of Mn on Fe (14). Previous work (3) indicated that FeEDDHA at 113 and 227 g, plus 1620 g $(NH_4)_2SO_4$, per tree induced Mn deficiency in bearing 'Sungold' peach.

Roy (5), in Florida, found that soil applications of 2.72 kg of $MnSO_4$ per tree to 19-yr-old 'Parson Brown' orange trees (*Citrus sinensis* Osbeck) increased the Mn concn in leaves, accelerated sugar formation in the fruit, and improved fruit color. Smith and Rasmussen in Florida (7) showed that soil-applied $MnSO_4$ at 33.63 and 67.24 kg metal equivalent per ha increased the Mn concn in 2-yr-old 'Valencia' orange (*Citrus sinesis* Osbeck) on 'Rough Lemon' [*Citrus jambhiri* Lush (Macf.)] rootstocks. Beyers and Terblanche (1) in South Africa found that 3 kg $MnSO_4$ and compost applied in holes in the soil around peach trees growing in alkaline soils corrected Mn deficiency. My purposes were to induce Mn deficiency in bearing 'July Elberta' peach trees with 113 and 227 g of FeEDDHA and attempt to correct the Mn deficiency with Mn chelate (MnEDTA).

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Materials and Methods

Nine Fe and Mn treatments: no-fertilizer controls, and 2 levels of Fe, each with 4 levels of Mn, were applied to Fe-chlorotic 'July Elberta' peach trees. The treatments in g per tree, are shown in Table 1. FeEDDHA was applied annually, 1968–1972: MnEDTA was applied annually, 1970–1972. Fe chelate was applied along the first 2 irrigation furrows on either side of the trees and covered with 2.54 to 5.08 cm of soil. The Mn chelate was applied along the second 2 irrigation furrows on either side of the trees and covered with 2.54 to 5.08 cm of soil.

Samples of 100 leaves per tree were taken from the middle of terminal shoots in June, July, August, and September. The samples were washed in 0.1N HCl, a detergent, "Joy", and deionized H_2O; dried in a forced draft oven for 12 hr at 65°C, ground in a Wiley Mill, passed through a 20-mesh screen, and placed in sample bottles for chemical analysis. Leaf-N was determined by the Kjeldahl method; and Fe, Zn, and Mn by atomic absorption spectroscopy. Phosphorus was determined with a Bausch and Lomb Spectronic 20 Spectrophotometer (venadomolybdophosphoric yellow method); and K by a Beckman Du with a flame attachement. Leaf color was measured as described earlier (3). Trunk and shoot growth, yield, and fruit size were determined as described earlier (3). Analysis of variance was calculated using methods of Snedecor (8).

The experimental design permitted comparisons of the long time peach tree response to Fe chelate applied at 113 and 227 g rates and the response to Mn chelate at various levels superimposed on the Fe chelate. Since increasing amounts of the elements were applied, it was possible to study the response as a polynomial regression. Within the range of the treatment levels, the mean responses to the supplements were fitted with linear, quadratic, and cubic polynomials to test the significance of the regression response and to allow interpolation to other levels where appropriate.

Results

Effects on tree appearance. FeEDDHA at 113 and 227 g changed Fe chlorotic 'July Elberta' peach leaves to green healthy ones (Tables 1, 4). Also FeEDDHA at 113 and 227 g induced Mn deficiency in the peach leaves after being applied for 2 years (1968–1969). Mn chelate and 113 or 227 g FeEDDHA had no significant effect on peach leaf color (Table 6).

Effects on fruit size and yield. FeEDDHA at 113 and 227 g minus MnEDTA increased size (diameter in cm) (Tables 1, 4) and yield (kg per tree) (Table 4) of the 'July Elberta' peaches when compared to the non-fertilized trees. Mn chelate applied with Fe chelate had no significant effect on size of peaches (Table 6). The regression coefficient for yield indicates that for each 454 g MnEDTA applied with 113 g FeEDDHA, the kg of fruit per tree increased by 2.64 (Table 6, 1st harvest, 1970).

Effects on growth. FeEDDHA at 113 and 227 g minus MnEDTA increased shoot growth (length in cm) when compared to the non-fertilized trees (Tables 1, 4). Also the Fe chelate at 113 and 227 g minus Mn-chelate did not increase trunk growth (cross-sectional square surface area in cm) when compared to the non-treated trees (Table 4). Mn chelate in the presence of both rates, 113 and 227 g of the Fe chelate did not increase shoot growth (Table 6). The regression coefficient for trunk growth (Table 6) indicates that for each 454 g MnEDTA applied with 113 g FeEDDHA, the trunk growth increased by 1.30 cm. Mn chelate in the presence of 227 g of FeEDDHA did not affect trunk growth.

Effects on Fe and Mn. FeEDDHA at 113 and 227 g increased the concn of Fe and decreased the concn of Mn in the peach leaves when compared to the untreated ones (Tables 1, 2, 5). Mn chelate applied with 113 and 227 g FeEDDHA (1970–1972) reduced the Fe concn and increased the Mn concn in 'July Elberta' peach leaves when compared to leaves on trees that received only 113 and 227 g FeEDDHA (Figs. 1, 2, 3, 4). Regression coefficient analyses indicated that there were significant linear trends in the Fe and Mn concn in peach leaves (Figs. 1, 2, 3, 4). The Fe (June, July, August, and September, 1970–1972) decreased in the leaves with each Mn increment with 113 g FeEDDHA. This decrease was curvilinear with the rate of decrease becoming greater at higher levels of applied Mn (Fig. 1). The Fe (June, July, August, and September, 1970–1972) decreased 2.04 ppm for each 680 g MnEDTA applied with 227 g FeEDDHA (Fig. 2). The Fe (June, 1970–1972) decreased in the peach leaves with each Mn increment applied with 113 and 227 g FeEDDHA (Figs. 3, 4). The Mn content (June, July, August, and September, 1970–1972) of the leaves increased .9 ppm for each 454 g MnEDTA applied with 113 g FeEDDHA (Fig. 1). The Mn concn (June, 1970–1972) increased in the leaves with each increment of MnEDTA applied with 113 and 227 g FeEDDHA. This increase was curvilinear with the rate of increase becoming greater at the higher levels of Mn applied.

Effects on other elements. The K concn of the peach leaves was

Table 1. Three year (1970–1972) effects of Mn chelate in the presence of 2 rates of Fe chelate on Mn, Fe, size of fruit, yield of fruit, and leaf color of 'July Elberta' peach trees.

Treatments	All dates		Size[z] (fruit diameter in cm)	Yield[z] (fruit kg per tree)	Leaf Color			Shoot growth (length in cm)
	Mn ppm	Fe ppm			Rd[y]	—"a" Green	"B" Yellow	
1. Control—no fertilizer	32	61	5.82	54.18	24.7	25.3	11.5	28.32
2. 113 g FeEDDHA	15	71	6.40	73.71	22.8	24.2	9.3	35.74
3. 113 g FeEDDHA + 454 g MnEDTA	17	68	6.53	80.35	22.6	24.0	9.0	37.59
4. 113 g FeEDDHA + 907 g MnEDTA	17	71	6.48	71.78	22.6	24.0	9.1	37.31
5. 113 g FeEDDHA + 1814 g MnEDTA	19	63	6.45	92.25	22.6	24.0	9.2	36.75
6. 227 g FeEDDHA	13	82	6.50	64.16	22.7	24.0	9.3	36.35
7. 227 g FeEDDHA + 680 g MnEDTA	12	76	6.30	78.25	22.7	24.0	9.2	36.17
8. 227 g FeEDDHA + 1361 g MnEDTA	13	77	6.55	63.08	22.6	24.0	9.0	36.65
9. 227 g FeEDDHA + 2722 g MnEDTA	16	72	6.50	71.41	22.6	24.0	9.1	35.79
L.S.D.[x] .05	3.75	7.53	.38	18.03	.58	.31	.63	6.96
L.S.D.[x] .01	5.00	10.03	.51	24.01	.78	.41	.84	9.27

[z] One year (1970) measurements.
[y] Rd-luminous reflectance. The lower the number, the greener the leaf.
[x] L.S.D. Least Significant Difference—Any 2 means must differ by L.S.D. to be declared statistically significant at the 5% or 1% level.

Table 2. Three year (1970–1972) effects of Mn chelate in the presence of 2 rates of Fe chelate on ppm Mn and Fe in 'July Elberta' peach leaves.

Treatments	June[z]		July[z]		August[z]		September[z]	
	Mn ppm	Fe ppm	Mn ppm	Fe ppm	Mn ppm	Fe ppm	Mn ppm	Fe ppm
1. Control—no fertilizer	31	69	32	63	33	60	33	51
2. 113 g FeEDDHA	16	84	15	74	14	69	15	57
3. 113 g FeEDDHA + 454 g MnEDTA	17	80	17	73	17	63	18	55
4. 113 g FeEDDHA + 907 g MnEDTA	16	83	16	73	17	69	17	59
5. 113 g FeEDDHA + 1814 g MnEDTA	20	77	19	67	18	58	20	50
6. 227 g FeEDDHA	13	92	14	84	12	79	13	71
7. 227 g FeEDDHA + 680 g MnEDTA	14	88	12	80	11	74	12	63
8. 227 g FeEDDHA + 1361 g MnEDTA	14	89	14	80	13	74	14	63
9. 227 g FeEDDHA + 2722 g MnEDTA	18	86	16	77	14	69	15	58
L.S.D.[y] .05	2.75	5.24	4.09	7.36	4.12	10.83	5.44	10.89
L.S.D.[y] .01	3.66	6.97	5.44	9.80	5.49	14.43	7.25	14.50

[z] Means of 3 years (1970–1972).
[y] L.S.D. Least Significant Difference—Any 2 means must differ by L.S.D. to be declared statistically significant at the 5% or 1% level.

Table 3. Three year (1970–1972) effects of Mn chelate in the presence of 2 rates of Fe chelate on N, P, K and Zn of 'July Elberta' peach trees.

Treatments	All dates	June	All dates	July	August	All dates	All dates
	N %	N %	P %	P %	P %	K %	Zn ppm
1. Control—no fertilizer	3.21	3.78	.161	.159	.141	1.76	27
2. 113 g FeEDDHA	3.22	3.74	.164	.160	.139	1.47	26
3. 113 g FeEDDHA + 454 g MnEDTA	3.14	3.58	.158	.154	.134	1.45	25
4. 113 g FeEDDHA + 907 g MnEDTA	3.18	3.69	.164	.158	.141	1.56	27
5. 113 g FeEDDHA + 1814 g MnEDTA	3.11	3.61	.154	.149	.129	1.37	25
6. 227 g FeEDDHA	3.29	3.80	.178	.177	.151	1.65	26
7. 227 g FeEDDHA + 680 g MnEDTA	3.25	3.73	.169	.165	.147	1.54	27
8. 227 g FeEDDHA + 1361 g MnEDTA	3.31	3.84	.173	.165	.146	1.62	27
9. 227 g FeEDDHA + 2722 g MnEDTA	3.24	3.73	.164	.162	.137	1.44	28
L.S.D.[x] .05	.09	.13	.02	.01	.01	.23	N.S.
L.S.D.[x] .01	.11	.17	.03	.02	.02	.31	

[x] L.S.D. Least Significant Difference—Any 2 means must differ by L.S.D. to be declared statistically significant at the 5% or 1% level.

Table 4. Comparative analysis of 3 year (1970–1972) data on the effects of 2 rates of FeEDDHA on size of fruit, yield of fruit, leaf color, and growth of 'July Elberta' peach trees.

Compared Treatments	Size[z] (fruit diameter in cm)	Yield[z] (fruit kg per tree)	Leaf Color Rd[y]	Leaf Color —"a" Green	Leaf Color "b" Yellow	Shoot growth (length in cm)	Trunk[w] growth
A. 113 g FeEDDHA	6.40**	73.71**	22.8**	24.2**	9.3**	35.74**	109.25
vs	vs	vs	vs	vs	vs	vs	vs
None (control)	5.82	54.18	24.7	25.3	11.5	28.32	117.50
B. 227 g FeEDDHA	6.50**	64.16*	22.7**	24.0**	9.3**	36.35**	132.23
vs	vs	vs	vs	vs	vs	vs	vs
None (control)	5.82	54.18	24.7	25.3	11.5	28.32	117.50

[z] One year (1970) measurements
[y] Rd-luminous reflectance. The lower the number, the greener the leaf.
[w] Cross sectional square surface area in cm.
* Significant at the 5% level.
** Significant at the 1% level.

Table 5. Comparative analysis of 3 year (1970–1972) data on the effects of 2 rates of FeEDDHA on the mineral composition of the leaves of 'July Elberta' peach trees.

Compared treatments	Mn ppm	Fe ppm	Zn ppm	N %	P %	K %
A. 113 g FeEDDHA	15**	71*	26	3.22	.164	1.47**
vs	vs	vs	vs	vs	vs	vs
None (control)	32	61	27	3.21	.161	1.76
B. 227 g FeEDDHA	13**	82**	25	3.29	.178*	1.65*
vs	vs	vs	vs	vs	vs	vs
None (control)	32	61	27	3.21	.161	1.76

* Significant at the 5% level.
** Significant at the 1% level.

reduced by FeEDDHA at 113 and 227 g when compared to the non-treated ones (Table 5). FeEDDHA at 227 g reduced the P concn of the leaves when compared to the untreated trees (Table 5). The Fe chelate did not affect the concn of N and Zn of the leaves when compared to the untreated ones (Table 5). The Mn chelate applied with 113 g FeEDDHA reduced the N of the peach leaves (Table 6).

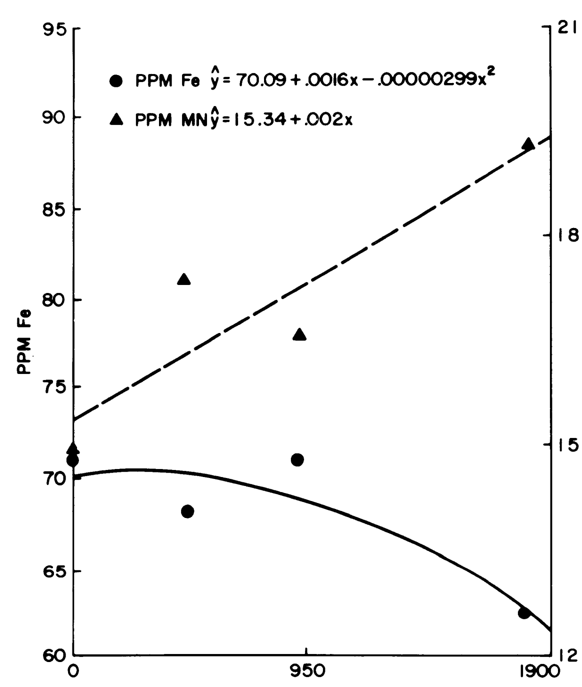

Fig. 1. Iron and Mn content of 'July Elberta' peach leaves as a result of MnEDTA applied with 113 g FeEDDHA to the soil (June, July, August and September 1970–1972).

Table 6. Response of 'July Elberta' peaches to Mn chelate in the presence of Fe chelate expressed as regression coefficients (1970–1972).

	113 g FeEDDHA Regression on 454 g increments of MnEDTA			227 g FeEDDHA Regression on 680 g increments of MnEDTA		
	Linear	Quadratic	Cubic	Linear	Quadratic	Cubic
Rd color of leaves[z]	–.00724	–.00043	.00095	–.00507	–.00055	–.00076
a color of leaves	–.00643	–.00046	.00099	–.00063	.00012	.00015
b color of leaves	–.00295	.00017	.00140	–.01162	–.00096	–.00041
Size of fruit (1970)	.00059	–.00003	–.00026	.00089	.00012	.00062
Yield 1st harvest (1970)	2.64*	.354*	.0524	–1.004	–.1314	–.2978
Total yield (1970)	2.28	.3090*	–.1259	.3460	.0303	–.3211
Shoot growth[y]	.03573	–.00043	–.01	–.0302	–.00469	.00284
Trunk growth[x]	1.30*	.12	–.04	–.31	–.03	.09
%N, all dates	–.00564*	–.0006	.00041	–.00166	–.00026	.00053
%N, June	–.00523	–.00047	.00125*	–.00289	–.00042	.00084
%P, all dates	–.00051	–.00006	.00006	–.00074*	–.00008*	.00005
%P, July	–.00057	–.00007	.0004	–.00082*	–.00007	.00004
%P, August	–.00058	–.00008	.00005	–.00087*	–.0001*	–.000001
%K, all dates	–.005	–.00088	.00056	–.01087	–.00132	.00071
ppm Zn, all dates	–.02077	–.00403	.01241	.08381	.00992	–.00799

[z] The lower the number, the greener the leaf.
[y] Length in cm.
[x] Cross sectional square surface area in cm^2.
* Significant at the 5% level.

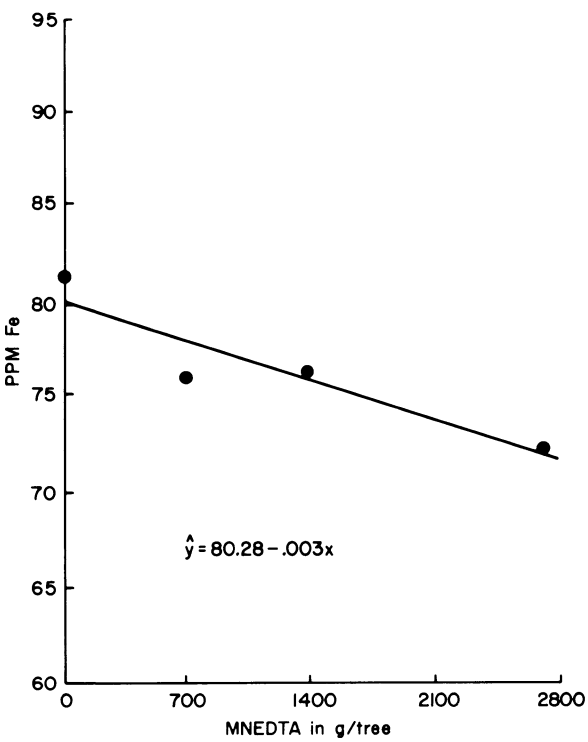

Fig. 2. Iron content of 'July Elberta' peach leaves as a result of MnEDTA applied with 227 g FeEDDHA to the soil (June, July, August and September 1970–1972).

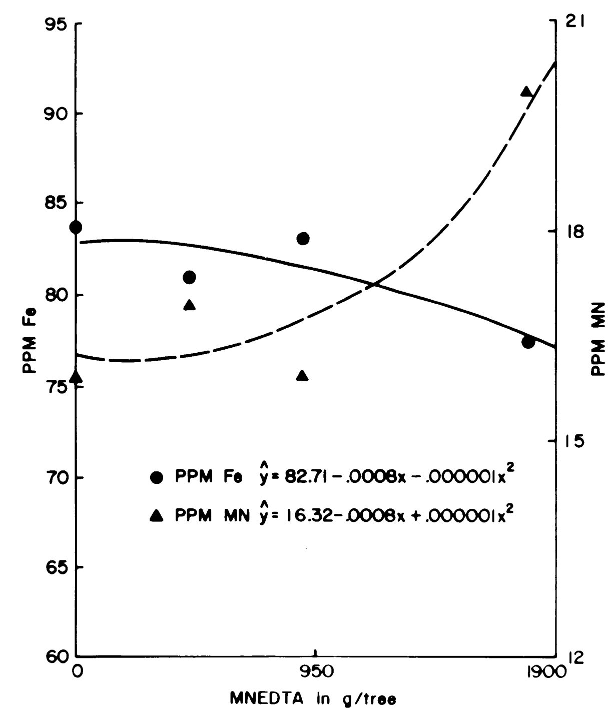

Fig. 3. Iron and Mn content of 'July Elberta' peach leaves as a result of MnEDTA applied with 113 g FeEDDHA to the soil (June 1970–1972).

The regression coefficient analysis (Table 6) indicates that for each 454 g MnEDTA applied with 113 g FeEDDHA, the N of the leaves decreased by .00564%. Mn chelate with 227 g FeEDDHA reduced P in the leaves. The regression coefficient analysis (Table 6) indicates that for each 680 g MnEDTA applied with 227 g FeEDDHA, the P of the leaves decreased by .00074%. The Mn chelate applied with Fe chelate had no significant effect on the K or Zn content of the leaves.

Discussion

FeEDDHA will correct lime-induced Fe chlorosis in 'Sungold' peach trees, but its overuse induces Mn deficiency. In a previous study (3), FeEDDHA at 227 g rate plus 1620 g $(NH_4)_2SO_4$ increased the Fe content of 'Sungold' peach leaves when compared to 56 or 113 g plus 1620 g $(NH_4)_2SO_4$. Also in prior studies, regression coefficients indicated that for each 56 g of FeEDDHA applied, the Fe in 'Sungold' peach leaves increased by 3.40 ppm and Mn decreased 2.82 ppm (3).

In our study both rates, 113 and 227 g, of FeEDDHA changed Fe chlorotic leaves to healthy green ones while the non-treated ones remained Fe chlorotic. Also, FeEDDHA at 113 and 227 g, induced Mn deficient peach leaves after being applied to the soil for 2 years (1968–1969). Mn deficient peach leaves have yellowish-green areas between main veins which are surrounded by deeper green. Epstein and Lilleland (2) found that deficiency symptoms in peach leaves could usually be associated with a Mn content less than 17 ppm. Our study showed that both rates 113 and 227 g of FeEDDHA increased the size and yield of fruit when compared to the non-treated trees

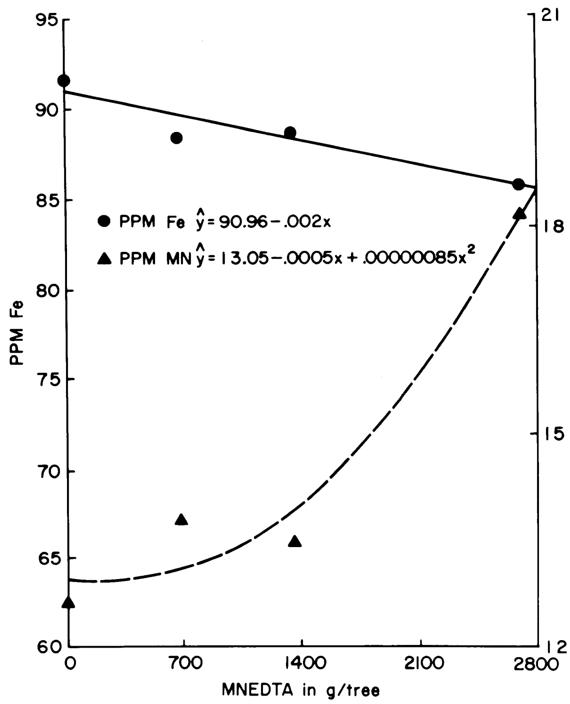

Fig. 4. Iron and Mn content of 'July Elberta' peach leaves as a result of MnEDTA applied with 227 g FeEDDHA to the soil (June 1970–1972).

(Table 4). Mn chelate applied in the presence of Fe chelate did not affect leaf color and size of fruit (Table 6). Mn chelate in the presence of 113 g FeEDDHA increased yield of fruit (Table 6). It did not increase yield applied with 227 g FeEDDHA (Table 6). Several workers have noted that soil applied MnEDTA is sometimes less effective than $MnSO_4$ on soils high in organic matter.

In this study, FeEDDHA at 113 and 227 g increased shoot growth when compared to the non-treated trees (Table 4). The Fe chelate did not increase trunk growth. Mn chelate in the presence of 113 g Fe chelate increased trunk growth 1.30 cm. In the presence of 227 g Fe chelate it did not increase trunk growth. Mn chelate in the presence of Fe chelate did not increase shoot growth (Table 6).

FeEDDHA at 113 and 227 g increased the concn of Fe and reduced the concn of Mn in peach leaves when compared to the leaves from untreated trees (Table 6). This result suggests that MnEDTA applied with 113 and 227 g of FeEDDHA will decrease the concn of Fe and increase the concn of Mn in 'July Elberta' peach tree leaves in a calcereous low organic matter soil. Takkar (11) reported the Mn^{2+} levels were increased about 10 fold in the soil with the combination of high temperature and organic matter. FeEDDHA at 113 and 227 g reduced the K concn of the peach leaves when compared to the nontreated ones (Table 4). The P concn of the leaves was increased by 227 g of the Fe chelate and not affected by the 113 g rate when compared to the non-treated trees (Table 5). Both rates of the Fe chelate did not affect the N and Zn concn of the peach leaves when compared to the non-treated ones (Table 5). Mn chelate in the presence of 227 g FeEDDHA reduced P and in the presence of 113 g reduced N (Table 6). The K and Zn concn of the leaves were not affected by Mn chelate being applied in the presence of Fe chelate.

More work is needed in determining methods of overcoming Mn deficiency induced by the application of FeEDDHA.

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