Trunk injection corrects iron and zinc deficiency in pear trees

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The usual methods of treating iron and zinc deficiencies in pear trees are costly and often only partially effective. The development of pressure injection equipment (*California Agriculture*, December 1976) and the wide use of Terramycin for treatment of pear decline have created interest in the possibility of injecting these nutrients directly into pear trees and of combining the nutrient and antibiotic treatments in one application.

Mild to severe iron chlorosis occurs in orchards in some areas of California where soils are alkaline or high in lime. Often the problem is limited to some areas of an orchard or to some trees. A severe deficiency stunts tree growth and decreases crop production.

Methods commonly used to correct iron chlorosis include one or more of the following procedures: acidifying the soil with large quantities of sulfur; applying iron chelates in a trench around each tree; and using foliage sprays containing iron. Usually these treatments only partially correct the deficiency, and either the materials or the labor required is costly.

Zinc deficiency is much easier to correct, except in severe cases; foliar zinc sprays applied in the fall or spring usually solve the problem. However, foliar applications will not correct severe zinc deficiencies that occur in orchards on old corral sites or in areas with very low soil zinc and high soil pH.

After some preliminary injection work in 1974 and early 1975 to develop the general concentration range and to find materials that showed promise without severe phototoxicity, plots were established in 1975 and 1976 in Lake, Los Angeles, and San Benito counties. Materials used in these trials were Fe 138 chelate, Fe 330 chelate, ferrous sulfate, and zinc sulfate.

The tests were designed to determine which was the best material for correcting iron or zinc deficiency, whether injection of deficient trees was successful, how long the treatment would remain effective, and if the material could be combined with other treatments.

A pressure injection machine at 200 psi was used to inject two Lake County orchards on September 11, 1975, and chlorosis was rated on May 19, 1976. Because one orchard showed slight zinc deficiency along with severe iron chlorosis, zinc was also included in the test in that orchard. Table 1 shows the results.

About 1 minute was required to inject 1 quart of the zinc solution at 200 psi. At the same pressure the Fe 300 + Zn EDTA solution required 1½ to 2 minutes, and the Fe 138 alone required 3 to 4 minutes for injection. This problem of iron chelates decreasing the injection rate had not been noted before. Further tests confirmed that the injection rate was decreased when either of the iron chelate materials was used.

The second Lake County orchard was treated with Fe 138 and Terramycin to evaluate combinations. All trees selected had approximately 9 inches to 1 foot of terminal growth, and all new growth had stopped. The trees were moderately chlorotic. Results are given in table 2.

One 50-year-old orchard was injected with iron in Los Angeles County on October 24, 1975, with evaluations made May 25, 1976. Ferrous sulfate was included to see if the injection rate might be increased and if more total iron could be injected without phytotoxicity. During injection the ferrous sulfate solution moved into trees at the same rate as a water treatment, whereas the Fe 330 required about twice as long to inject. Table 3 gives results of the iron injections.

A large replicated block of uniform 13-year-old trees was injected June 3, 1976, in Lake County to evaluate rates and concentrations of materials. Results showed that ferrous sulfate was easier and cheaper to use and was less phytotoxic (table 4).

Five 8-year-old Bartlett pear trees in Santa Clara County showing severe little leaf and terminal dieback due to zinc deficiency were injected with one quart of 1 percent zinc sulfate solution on May 19, 1976. No response was noticed in 1976, but growth on the injected trees was normal during 1977. The check trees continued to show severe zinc deficiency.

Discussion

Iron chlorosis in Bartlett pear trees can be corrected by injecting a ferrous sulfate or iron chelate solution into tree trunks using 150 to 200 psi pressure. In these trials, 1 to 2 quarts of a 1 or 2 percent solution of ferrous sulfate injected into mature trees corrected most of the iron chlorosis. Experience is limited to mature trees. Treatment of young trees should be handled with extreme care. Localized portions of some trees continued to show chlorosis following treatment, but deficiency in these limbs was corrected by additional injections. Terra-

mycin was shown to be compatible with the treatments of one of these tests as well as in other research work.

Ferrous sulfate has several advantages over iron chelates. Correction of iron deficiency with ferrous sulfate has been equal to that obtained with chelate materials. Ferrous sulfate is less expensive, has shown much less phytotoxicity than the other products tried, and can be injected faster than either Fe 330 or Fe 138.

Similarly, zinc sulfate appears to be an effective, inexpensive zinc material to use for correction of zinc deficiency. Correction of zinc deficiency has not been as spectacular as the results for iron deficiency, but correction was obtained using 1 quart of 1 percent solution on 8-year-old trees.

Trees treated with the higher rates of ferrous sulfate remained normal for 2 years following injection. Numerical evaluations from the second season after injection were not included, because the grower injected the check trees and all other chlorotic trees in the plot in the fall of 1976. Evaluation of the remaining trees showed that 2-year correction of iron chlorosis can be obtained with 1 or 2 quarts of 2 percent ferrous sulfate solution. Future evaluations will determine if the high rates will give longer correction.

The cambial area in many shoot tips of trees injected with iron became darkened a few days after injection. Samples taken from these shoot tips indicated high concentrations of iron. Injected material appeared to be quite mobile, moving upward in the xylem, where it was deposited near shoot and spur tips. The deposited material disappeared after 2 to 3 months, probably having been redistributed within the tree. The discoloring of the cambial area caused no physical damage of shoots, provided the iron dosage was not excessive.

Another problem was noted in a few orchards where growers injected with iron material into pear trees in the late summer. On moisture-stressed trees, the injection has shocked some small branches into a new flush of growth with some bloom. The loss of this bloom did not reduce the crop the following year. Maximum recommended rates have caused more shock than lower dosages.

In summary, 1 quart of either 1 or 2 percent ferrous sulfate solution injected into mature Bartlett pear trees corrected severe iron deficiency for at least 1 year. Larger pear trees have been injected with 2 quarts of 2 percent ferrous sulfate without phytotoxicity. Pressure injection of 1 quart of 1 percent zinc sulfate solution also controls zinc deficiency for the same period.

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TABLE 1. Injections of Iron and Zinc into 12-year-old Bartlett Pear Trees, Treated September 11, 1975 and Evaluated May 19, 1976

Material	Rate	Concentration*	Chlorosis†
	qt/tree		
Check	0	0	4.0 c
Fe 138	1	1%	1.6 a
ZnEDTA	1	1%	3.0 b
Fe 138 + Zn EDTA	1	1% + 1%	1.6 a
Fe 330 + Zn EDTA	1	1% + ½%	1.4 a

*All nutrient concentrations on a percent-by-weight basis (pounds material/pounds water X 100).
†Chlorosis visually rated on a scale of 0 to 5: 0 = no chlorosis; 1 = very mild—slight yellowing of some leaves; 2 = mild—leaves with mild to moderate chlorosis on some limbs; 3 = moderate—over 50 percent of leaves on tree moderately chlorotic; 4 = severe—most leaves yellow, entire tree showing symptoms; 5 = very severe—all leaves yellow, with defoliation. Values followed by different letters differ significantly at the 0.05 level.

TABLE 2. Injections of Iron and Terramycin into 40-year-old Bartlett Pear Trees, Treated September 11, 1975 and Evaluated May 19, 1976

Material	Rate	Concentration*	Chlorosis†	Trees with increased vigor
	qt/tree			
Check	0	0	2.2 b	0
Fe 138	1	1%	1.4 a	20
Terramycin	1	600 ppm	1.7 ab	40
Fe 138 + Terramycin	1	1% + 600 ppm	1.2 a	60

*All nutrient concentrations on a percent-by-weight basis (pounds material/pounds water X 100).
†Chlorosis visually rated on a scale of 0 to 5: 0 = no chlorosis; 1 = very mild—slight yellowing of some leaves; 2 = mild—leaves with mild to moderate chlorosis on some limbs; 3 = moderate—over 50 percent of leaves on tree moderately chlorotic; 4 = severe—most leaves yellow, entire tree showing symptoms; 5 = very severe—all leaves yellow, with defoliation. Values followed by different letters differ significantly at the 0.05 level.

TABLE 3. Injections of Iron into Bartlett Pear Trees, Treated October 24, 1975 and Evaluated May 25, 1976

Material	Rate	Concentration*	Chlorosis†
	qt/tree		
Check	0	0	2.6
Fe 330	1	1%	1.7
$FeSO_4$	1	½%	1.8

*All nutrient concentrations on a percent-by-weight basis (pounds material/pounds water X 100).
†Chlorosis visually rated on a scale of 0 to 5: 0 = no chlorosis; 1 = very mild—slight yellowing of some leaves; 2 = mild—leaves with mild to moderate chlorosis on some limbs; 3 = moderate—over 50 percent of leaves on tree moderately chlorotic; 4 = severe—most leaves yellow, entire tree showing symptoms; 5 = very severe—all leaves yellow, with defoliation. Values followed by different letters differ significantly at the 0.05 level.

TABLE 4. Injections of Iron into 13-year-old Bartlett Pear Trees, Treated June 3, 1976 and Evaluated on Dates Indicated

Material	Rate	Concentration*	Chlorosis†		Phytotoxicity‡	
	qt/tree		7-2-76	11-4-76	6-17-76	11-4-76
$FeSO_4$	1	½%	1.8 a	0.4 ab	1.4	0 a
	1	1%	1.9 a	0 a	1.6	0 a
	½	2%	1.9 a	0.4 ab	0.6	0.4 a
	1	2%	1.6 a	0 a	2.4	0.4 a
	2	2%	1.6 a	0 a	1.7	0.2 a
	1	4%	1.4 a	0.2 ab	2.4	1.2 b
Fe 330	1	1%	1.8 a	0.8 b	5.6	2.6 d
	1	2%	1.8 a	0.6 ab	6.3	1.8 bc
	1	4%	2.0 a	0.6 ab	5.8	2.0 cd
Check	0	0	4.6 b	4.2 c	1.2	0 a

*All nutrient concentrations on a percent-by-weight basis (pounds material/pounds water X 100).
†Chlorosis visually rated on a scale of 0 to 5: 0 = no chlorosis; 1 = very mild—slight yellowing of some leaves; 2 = mild—leaves with mild to moderate chlorosis on some limbs; 3 = moderate—over 50 percent of leaves on tree moderately chlorotic; 4 = severe—most leaves yellow, entire tree showing symptoms; 5 = very severe—all leaves yellow, with defoliation. Values followed by different letters differ significantly at the 0.05 level.
Phytotoxicity rated on a scale of 0 to 10: 0 = no burned leaves; 10 = all leaves showing severe burn.