Injections for Citrus Trees

phosphorus and potassium given lemon trees by injections in experimental study of nutrient deficiencies

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The injection method of supplying nutrient elements to trees was chosen at the outset of a study as to whether citrus trees would respond to potassium applications.

If leaf patterns that occur on orange, lemon, and grapefruit trees indicate, on the basis of leaf analysis, that the patterns are associated with a low potassium content an additional tool may be available for assessing the potassium status of citrus trees.

The injection technique for supplying potassium was chosen—over spray applications or soil treatments—because it is rapid, insures the uptake of potassium by the tree, and eliminates questions which might arise regarding potassium fixation in the soil or uptake by roots.

The injection method of supplying nutrient elements to trees may be of limited commercial value, but the results obtained with its use in these trials proved to be highly significant.

In November, 1948, two experimental trials, involving the injection of a solution of 200 grams of di-potassium phosphate—in three liters of water—into lemon trees, were established in Ventura County lemon orchards. One trial was located near Saticoy, the other near Fillmore. At Saticoy the trees are Thornton Eureka lemon on sour orange rootstock. At Fillmore the trees are Wheatley Eureka lemon on rough lemon rootstock. Leaves of Wheatley Eureka lemon on sweet orange rootstock, on this same property at Fillmore, show far less pattern than do leaves of this same scion on rough lemon rootstock, which suggests the possibility of a rootstock effect.

Prior to injection, leaf samples were collected from both orchards from all trees selected for treatment. Analyses of the dry matter of these leaves immediately following collection showed: calcium 5.34% to 8.82%, magnesium 0.249% to 0.528%, potassium 0.213% to 0.392%, and phosphorus 0.042% to 0.074%. The potassium content of the leaves was low and the total phosphorus content of these same leaves was exceedingly low. The question at once raised by these data was whether potash deficiency or phosphorus deficiency or a combination of both was involved.

Leaf samples were taken for analysis from the injected trees one week after the November, 1948, injections to determine the distribution of the potassium and phosphorus in the leaves.

Potassium was raised from an average value of 0.285% to 0.456% and phosphorus was raised from an average value of 0.054% to 0.158%.

Periodic observations were made on all treatments during the winter of 1948 and 1949. A slight leaf burn resulting from injection was evident on a few leaves of the injected trees about one week after treatment. These leaves subsequently dropped. During the winter no particular differences were noted between treated and untreated trees. The severe cold and wind in January produced a great deal of leaf fall on both properties regardless of treatment, and by February a number of trees were in relatively poor condition.

In April, however, the injected trees in the orchard near Fillmore showed considerably more new growth and bloom than the untreated trees and were of much greener color. Injected trees on the property near Saticoy showed considerably more bloom than untreated trees but new growth and the color of the leaves, while improved, were not as outstanding as on the property near Fillmore.

By May the injected trees on the Fillmore orchard were so outstanding with respect to leaf growth, color and vigor that additional experiments were initiated to see if this stimulation of tree growth could be reproduced and if so, to determine which element, phosphorus or potassium or a combination of both, was responsible for the stimulation.

On May 25, 1949, a new series of tree injection experiments was established at the orchard near Fillmore. All new injection work was now confined to this property since the differences produced by treatment were so outstanding. In an attempt to reproduce the stimulation re-

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Eureka lemon trees on rough lemon rootstock in orchard near Fillmore: *LEFT*, check tree—untreated; *RIGHT*, tree injected with 200 grams di-potassium phosphate in three liters of distilled water. Soil applications of nitrogen were similar for both trees.

AIR-CARRIER

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Dusting equipment for the application of dry dust materials in orchards has not been very satisfactory. Undoubtedly this has been due to the employment of a low volume of air at a comparatively high velocity and the uneven feeding of the dust mixture into the air stream.

For the past two years, experiments have been undertaken in designing an orchard duster which employs a high volume of air at a lower velocity and the use of precision feed of the dust into the air stream. The benefits derived from the use of a larger volume of air are apparent and improvements have been made in the feeding devices.

Some manufacturers have designed dusting attachments which can be mounted on the rear of their air-carrier equipment. In this way the air volume of the sprayer may be used for both liquid and dust applications. In one model the dust is fed directly into the fan housing and in another model the dust is fed into the air stream as it leaves the discharge head.

Volute Attachments

The volute attachment for air-carrier equipment is used especially in very large trees or where the foliage is very dense—walnuts, olives, citrus—and all the air discharge is directed to one side of the equipment.

The discharge openings are much wider and longer and the air stream is directed to the tree tops. Though the shape may vary from a large flat horn to that of a long wide boom the effect is largely directional. The use of oscillating vanes in the opening of the discharge stirs the foliage and permits a more uniform wetting.

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Specifications of Equipment Designed for Bulk and Semi-Concentrate Liquid Applications

Model*	Engine hp	Type of fan	Discharge		Air		Tank capacity gallons
			Type head	Nozzles	Volume cubic feet	Velocity mph	
A	110	axial flow	2 sided	80	43,000	127	500
B	55	axial flow	2 sided	76	30,000	127	400
C	110	centrifugal	2 sided	44	30,000	125	400
D	40	centrifugal	1 sided	44	15,000	125	300
E	145	centrifugal	volute	60	60,000	100	500
F	125	axial flow	2 sided	34	30,000	165	400
G	35	axial flow	1 sided	16	15,000	165	300
H	92	centrifugal	1 sided	26	15,000	125	300

* Letters designate available commercial spray equipment.

Specifications of Equipment Designed for Concentrated Liquid Applications

Model*	Engine hp	Type of fan	Discharge		Air		Tank capacity gallons
			Type head	Nozzles	Volume cubic feet	Velocity mph	
A	45	centrifugal	1 sided	6	20,000	110	300
B	26	axial flow	1 sided	6	13,000	140	200
C	5	axial flow	1 sided	8	7,500	75	200

* Letters designate available commercial spray equipment.

Specifications of Equipment Designed for Dust and Concentrated Liquid Spray Applications

Model*	Engine hp	Type of fan	Discharge		Air		Capacity	
			Type head	Nozzles	Volume cubic feet	Velocity mph	Tank	Hopper
A	24	axial flow	fishtail	4	10,000	200	50 gals.	150 lbs.
B	30	centrifugal	double fishtail	8	3,500	175	100 gals.	150 lbs.

* Letters designate available commercial spray equipment.

INJECTIONS

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sulting from the original injection of dipotassium phosphate, six additional trees were injected with a solution containing 200 grams of this salt.

To differentiate between a potassium and a phosphorus response, five trees were injected with four liters of a 0.1 normal solution of mono-calcium phosphate and five trees were injected with three liters of solution containing 250 grams of potassium citrate. Three trees were injected with distilled water to determine if the injection reaction itself was stimulating the trees. All trees in this orchard received uniform nitrogen application to the soil.

Frequent observations were made on these treatments and there is no doubt that a stimulation of vegetative growth was produced by the new injection series. The combination of phosphorus and potassium appeared to produce the best growth. Considered separately, phosphorus seemed to produce a greater response than potassium, which, in turn, appeared to produce more growth than nitrogen alone did on the check trees. Injection of distilled water produced no effect whatsoever on the trees. On the basis of these results and of supplementary studies with sand cultures, it appeared that the leaf symptoms for potassium deficiency in the field might be a combination of both the leaf patterns of potash and phosphorus deficiency, or some secondary effect resulting from a deficiency of one or the other or both of them.

While it is recognized that the data reported in this article were obtained from a single citrus variety—Wheatley Eureka lemon on rough lemon stock—growing in a very limited soil area, the results obtained to date indicate that the relationship of these findings to other citrus problems should be established. With respect to the limited area involved, it should be noted that the soil in the experimental plots at Fillmore is a Yolo gravelly, fine sandy loam, with a pH—the measurable acidity and alkalinity—of 5.8 which is moderately acid, in the depth to six inches and a pH of 6.3—slightly acid—in the depth of six to 18 inches. The quan-

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DROP

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teresting to speculate on even how much more effective 2,4,5-T in the amine form might be.

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DWARFING

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are very sensitive to cold and at Riverside have shown more damage from cold than any of the other combinations. Fruit produced on this stock is very low in acid and has a tendency to be somewhat insipid. The stock itself is very susceptible to gummosis. It is questionable if this stock has sufficient merit to warrant its usage in California.

The Cuban Shaddock produces substandard sized trees. Marsh grapefruit trees on this stock after 14 years of age are 70% as large as trees 17 years old on sweet root. They produced as much fruit in the first 10 years as the trees on sweet root, but in the last six years have yielded only 71% as much. Washington Navel orange trees on this stock at 14 years of age are 45% as large as 17-year-old trees on sweet root. Production for the first 10 years is about the same as on sweet root, but in the last six years has dropped to 80% of the check trees. Eureka lemons on this stock in 1947 were 48% as large as trees on sweet root which were three years older. They produced 66% as much fruit for the first 10-year period as trees on sweet root. Unfortunately, there were no trees on sweet root of the same age for comparison, but obviously the difference in size and production of the two combinations cannot be entirely accounted for by the three years difference in their ages. Trees on this stock tend to have a heavy early production, but this is not maintained in later years. This rootstock appears to be fairly susceptible to footrot. In general, its effect on the top is to produce poorer fruit quality and a tendency toward greater damage from low temperatures than when conventional rootstocks are used.

Eureka lemon cuttings budded to Valencia oranges were also part of the orange rootstock trials. After 18 years these trees approximate 8½ feet in height as compared to comparable trees on sweet root which are 16 feet in height. They have produced 60% as much fruit in the first 10 years, but only 42% as much in the last six. Fruit quality is below average and the combination is easily damaged by low temperatures. In addition to being susceptible to gummosis this rootstock is susceptible to shellbark. It may also be another source of psorosis if the parent lemon trees were carrying the disease. As a rootstock it has little to recommend it other than the dwarfing tendency.

Most citrus growers in California prefer those combinations which produce large or standard sized orchard trees. While in general tree size and fruitfulness are associated, they are not always correlated. Long-lived, healthy, and productive dwarfed combinations may have a definite place in plantings made by the home grower and perhaps the orchardist.

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OLIVE

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ceding the 1949 crop only and bore 124 pounds per tree as compared with 28 pounds for the check trees. All the 1949 girdling in this orchard was done on February 15.

There was a reduction in fruit size of the heavier crop on the girdled trees, but this was offset easily by the greatly increased yields.

Using the yield records and size grades, and computing on an acre basis from the 15 girdled trees in this test orchard the increase in gross return in 1949 over nongirdled trees would amount to approximately $620 per acre at 50 trees per acre.

Girdling of olive trees is not recommended at present for use as a genreal practice but it may be worthwhile to try—in an experimental manner—on a limited number of trees in orchards which have a habit of blooming heavily but failing to set good crops.

Under such conditions the following suggestions are made:

1. The primary scaffold branches should be girdled about the middle of February, with one or two branches on each tree left ungirdled to supply the roots with carbohydrates until the girdling cuts heal over.

2. Girdling cuts are made most easily with a grape-girdling knife in areas with smooth bark. The soft bark should be removed down to the hard inner wood in a strip, not to exceed one fourth inch in width, completely around the branch.

3. The cuts should be covered immediately with either hot grafting wax or with an asphalt emulsion grafting compound. In orchards infected with Olive Knot provision should be made to prevent infection starting in the cuts. Also the girdling knives should be dipped after each cut in a disinfectant to prevent spread of the disease.

4. To determine accurately whether the girdling has been beneficial it is desirable to obtain yield records during harvest from the girdled trees and from adjacent trees of comparable size.

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tity of dilute acid soluble phosphorus and potassium in this soil is very low and correlates well with the low phosphorus and potassium content of the leaves.

Lemon orchards with the leaf spotting referred to here have been noted in parts of Santa Barbara, Ventura, Tulare, and San Diego counties. More recent analyses show that the leaves obtained from these same areas are also very low in phosphorus.

Apropos of leaf analysis as a diagnostic tool, it can be stated that so far, responses to tree injection of phosphorus and potassium have been obtained only where exceedingly low levels of these elements were found in the leaves. Previous tree injection work using mono-calcium phosphate and di-potassium phosphate in Ventura, Orange, and Riverside counties failed to produce response in trees having phosphorus and potassium levels considered adequate by current standards.

This is the first time in California that citrus trees in the field—with leaves of a known low phosphorus and potassium content—have responded to phosphate and potassium treatment.

This response of citrus to phosphorus in southern California is of interest in the light of previous failures of many field trials with citrus to show responses from these elements.

It remains for future work to determine whether the response of lemons to phosphorus and potassium injections reported in this article can be duplicated by soil treatments.

It seems certain, based on the extensive leaf analysis surveys and soil studies of phosphate and potash in citrus groves made previously, that many groves are amply supplied with these constituents.

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