CITRUS MUTUAL STATEMENT BEFORE

STATE WATER RESOURCES CONTROL BOARD

WEDNESDAY, MAY 23, 2012

MY NAME IS BOB BLAKELY AND I SERVE AS DIRECTOR OF INDUSTRY RLEATIONS FOR CALIFORNIA CITRUS MUTUAL.

CITRUS MTUUAL IS A VOLUNTARY MEMBERSHIP NON-PROFIT TRADE ASSOCIATION COMPRISED OF 2200 GROWER MEMBERS; THIS MEMBERSHIP EQUALS 65% OF CALIFORNIA'S 285,000 PRODUCING ACREAGE.

OVER 70% OF CALIFORNIA'S CITRUS ACREAGE IS WITHIN THE SCOPE OF THIS REPORT - THUS THE REASON FOR OUR TESTIMONY - INASMUCH WE HAVE SERIOUS CONCERNS ABOUT THE CONCLUSIONS AND RECOMMENDATIONS BEING DRAWN FROM THE REPORT

REMEMBER THAT THIS IS A REPORT OF HISTORICAL DATA – NITRATES IN GROUNDWATER IS NOT A NEW PHENOMA. LOST WITHIN THE REPORT IS THE TERM LEGACY ISSUE -MEANING THE PROBLEM WAS IDENTIFIED AS EXISTING OVER 25 YEARS AGO.

THE LEGISLATURE FIRST BECAME AWARE OF THE ISSUE IN 1988 AND WHILE MANY IN AGRICULTURE HAVE RESPONDED PROACTIVELY - PREVIOUS ADMINISTRATIONS HAVE CHOSEN TO DO NOTHING.

THEREFORE, OUR CONCERNS ABOUT THE INCOMPLETE CONCLUSIONS DERIVED. MANY OF US IN AGRICULTURE HAVE IMPROVED PRACTICES TO MITIGATE THE PROBLEM - AND THAT IS NOT RECOGNIZED.

FOR EXAMPLE CITRUS HAS CONVERTED TO MICRO IRRIGATION, INCORPORATED MORE EFFICIENT FERTIGATION PRACTICES INTO NUTRIENT MGT PROGRAMS AND LEAF, SOIL AND WATER ANALYSIS ARE STANDARD OPERATING PROCEDURES.

A CURRENT UCCE CITRUS NEWSLETTER STATES THAT THE ADOPTION OF LEAF TEST ANALYSIS AND STANDARDS RESULTED IN REDUCING NITROGEN APPLICATIONS BY FIFTY PERCENT.

WE ESTIMATE THAT 90% OF OUR TOTAL ACREAGE OPERATES UNDER THE PROGRAMS MENTIONED ABOVE. IMPROVEMENTS - SINCE WE FIRST IDENTIFIED THE PROBLEM THAT ARE NOT INCLUDED WITHIN THE REPORT.

WE COMMEND THE AUTHORS FOR NOTING THAT SOME OF THIS DATA IS "MESSY" AND THAT SPECIFIC CONCLUSIONS SHOULD NOT BE DRAWN. YET MANY CHOOSE TO DO SO IGNORING THE ERRONEOUS ASSUMPTIONS BEING DRAWN.

1) THERE IS NO CONSIDERATION FOR AMOUNT OF NUTRIENT BEING RETAINED IN THE TREE, THUS THE ASSUMPTION THAT IT IS LEACHING INTO GROUNDWATER. THE AUTHORS ASSUME 50% OF THE AMOUNT APPLIED IS LEACHED.

2) THERE IS NO CONSIDERATION FOR NEW FARMING PRACTICES. THE MOST OBVIOUS IS THAT WHEN THE PROBLEM WAS FIRST IDENTIFIED FLOOD IRRIGATION WAS A STANDARD PRACTICE.
3) WHILE THE AUTHORS ADMIT TO DATA GAPS THERE ARE THOSE WHO CHOOSE TO IGNORE THIS STATEMENT AND SEEK NEW REGULATIONS AND POLICIES WITHOUT A SOLID FOUNDATION OF INFORMATION.
4) THE REPORT MISSES AN IMPORTANT SALIENT FACT – PRODUCTION AGRICULTURE IS A CONSUMER OF NITROGEN INPUTS AND NO LONGER A GENERATOR OF NITROGEN WASTE. THE COST OF THIS INPUT HAS TRIPLED IN THE PAST 20 YEARS – THAT IN ITSELF DICTATES MORE EFFICIENT PRACTICES.
5) THE PARTNERSHP OF UC/ANR AND THE CITRUS INDUSTRY IDENTIFIED AS LONG AGO AS 1978 BETTER PRACTICES FOR BOTH THE ENVIRONMENT AND OUR CITRUS REGARDING FERTILIZER USE. THAT INITIAL RESEARCH HAS BEEN UPDATED TWICE. OUR LAST REPORT CLEARLY SHOWED PRACTICALLY NO INCREASE IN NO3 POLLUTION OF GROUND WATER ASSCOIATED WITH MODERN APPLICATION METHODS.

CCM RECOMMENDATIONS

1) WE BELIEVE THE REPORT HAS VALUE BECAUSE IT CLEARLY IDENTIFIED AN EXISTING PROBLEM THAT NEEDS TO BE RECTIFIED. WE BELIEVE THE STATE BOARD SHOULD EXPLORE PROGRAMS SUCH AS BOND FUNDS ESTABLISHED FOR SOLUTIONS IN THIS AREA. WE BELIEVE THE STATE BOARD CAN - IN SHORT ORDER - IDENTIFY OTHER SOLUTION PATHS THAT FIX TODAYS PROBLEM TODAY FOR OUR CITIZENS.
2) WE BELIEVE THE ALLEGED PROBLEM FOR TOMORROW REQUIRES ADDITIONAL EVALUATION AND WE RECOMMEND THAT THE BOARD PARTNER WITH UC/ANR TO CLEARLY IDENTIFY HOW TODAY'S USE PRACTICES WILL AFFECT TOMORROW'S CONTAMINATION ISSUE.

    A) WE BELIEVE THE STATE BOARD SHOULD EMPOWER ANR TO DETERMINE HOW MUCH "N" IS MOVING OUT OF THE ROOT ZONE UNDER CURRENT PRACTICES AND ONCE IDENTIFIED BY COMMDOITY AND SOIL TYPE RECOMMEND MORE EFFICIENT PRACTICES.

    B) WE BELIEVE OTHER COMMODITIES MAY HAVE RESEARCH SUCH AS OUR INDUSTRY THAT CAN ASSIST IN DEVELOPING A SOLID FOUNDATION OF INFORMATION. WHERE THAT DATA DOES NOT EXIST ANR CAN INITIATE THE APPROPRIATE RESEARCH TO MAKE DEFINITIVE INTERPETATIONS.

IN CLOSING THERE ARE CLEARLY TWO PATHS IDENTIFIED - BOTH OF WHICH REQUIRE ACTION STEPS BY THE STATE BOARD.

TOGETHER ALL STAKEHOLDERS MUST IDENTIFY A SOLUTION TO ELIMINATING CONTANIMATION OF TODAY'S GROUNDWATER.

SECONDLY WE MUST HAVE BETTER INFORMATION - AS THE REPORT CLEARLY POINTS OUT - AS TO THE SCOPE OF THE PROBLEM FOR TOMORROW

THEN PARTNER WITH STAKEHOLDERS TO DETERMINE WHAT STEPS ARE NECESSARY.

HEALTHY FOOD SYSTEMS ◦ HEALTHY ENVIRONMENTS ◦ HEALTHY COMMUNITIES ◦ HEALTHY CALIFORNIANS

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Citrus Notes
Tulare County

Volume 10 Issue 1, May 2012

As provided for in Senate Bill SBX2 dealing with Nitrate in Groundwater the State Water Resources Control Board was charged to identify in collaboration with relevant agencies sources of groundwater contamination due to nitrates. A report was recently released by the University of California Davis with the results of its study on nitrates in groundwater. One of the contributors of nitrates mentioned in the report results from the use of nitrogen in agricultural production. The citrus industry of California adopted new technology developed by researchers at the University of California Riverside in the 1960's which established leaf sampling of an orchard and laboratory analysis of the sample and comparison of the results to established standards including nitrogen. Within a few years the industry had reduced applications of nitrogen by fifty percent. Today, fertilizer applications are generally founded on the results of leaf analysis.

Nitrogen Management

Nitrogen management research was the topic of a presentation at the recent Spring Citrus meeting conducted by the UC Cooperative Extension Office. Results of a nitrogen management research study conducted from 1995-2002 was presented by Dr. Mary Lu Arpaia, one of the researchers that conducted the trial. To see the full report, click on the link below.
http://cetulare.ucdavis.edu/Agriculture782/Citrus

The project was conducted in a mature navel orange orchard under a micro sprinkler irrigation system. Leaf analysis was conducted at the beginning, during and at the completion of the trial to measure the response of the trees to the various treatments. See Leaf Analysis Guidelines at the following website.
http://cetulare.ucdavis.edu/Agriculture782/Citrus
Methods of nitrogen application were evaluated; foliar only applied 1, 2, 4 times. Applications to the soil were injected into the irrigation system (fertigated) 1, 2, or continuous with each irrigation. Combinations of foliar and soil applied were evaluated as well. Timing of the foliar application was a single application in late May, two applications one in the winter and in late May, four applications late winter, prebloom, late May and thirty days after the late May. Timing of soil applications (fertigation) was a single application in late winter, split application in late winter and early summer and continuously with every irrigation from late winter through summer. Treatments also included combinations of foliar and soil applications at different rates of applied nitrogen. Fruit production and quality were measured for each treatment. Measurements of nitrate nitrogen in the soil solution below the root zone were made. As the amount of nitrogen applied to the soil increased there was a general trend toward higher nitrate nitrogen in the soil solution below the root zone. Nitrate nitrogen levels in the soil only treatments tended to be the highest at all nitrogen rates whereas the combination foliar/soil applications were lower than the soil only application. Little difference in the soil nitrate nitrogen concentrations could be related to the timing of the soil nitrogen application. Maximum yield was attained with 1.0-1.5 pounds of N per year per tree. Size distribution was not greatly influenced by treatment. Fruit from the higher nitrogen treatments had thicker peels with lower firmness levels. The method of N

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application did not influence this. In summarizing the results of the research, Dr. Arpaia made these points:

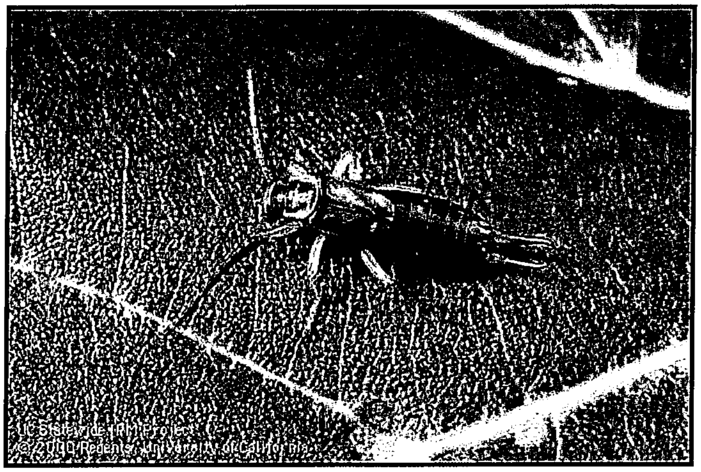
Increasing N results in increasing nitrate nitrogen below the root zone. The method of N application can influence this trend since treatments with foliar application had less nitrate nitrogen below the root zone.

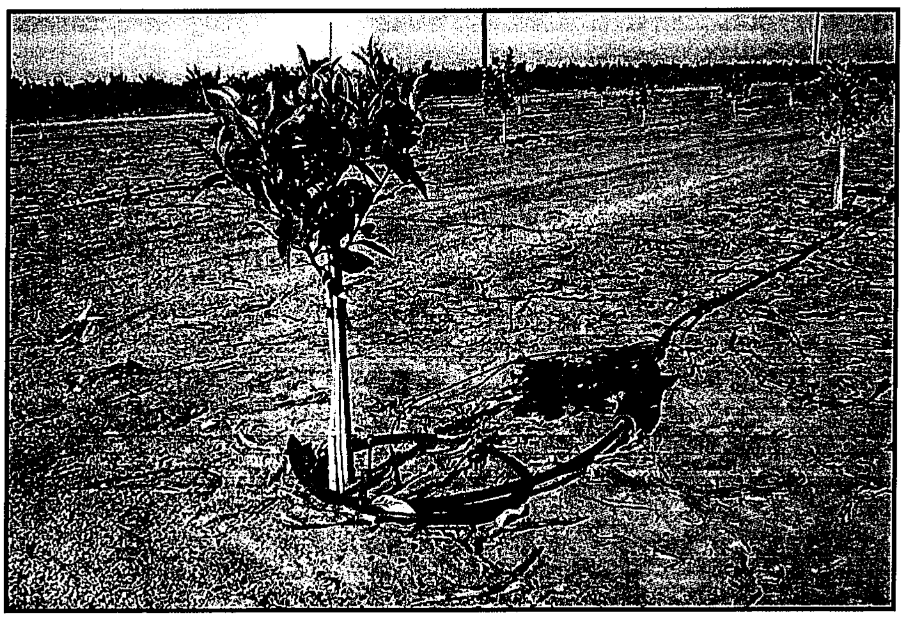
Maximum yield and lower soil nitrate-nitrogen levels can be achieved using a combination foliar/soil applied approach

<u>Tree Wraps</u>

Installing tree wraps on young trees provides protection to the trunk from applications of herbicides during weed management operations. Additionally, the wraps minimize light interception by trunk tissue thereby minimizing sucker growth. During hot weather tree wraps provide shade to the trunk and reduce the incidence of sunburn. With the increasing incidence of earwigs, damage to young trees and the tendency for the insect to congregate under the wraps, tree wraps are being removed. When wraps are removed a uniform coating of sun protective material should be applied to the trunk to protect against sun damage. Trunk surfaces should be monitored to ensure that a uniform coating is in place. Sun damage to unprotected trunk tissue can result in partial or complete girdling of the tree.

European Earwig





NUTRITION

CHAIRPERSON: DR J. BEN ROBINSON

EFFECTS OF FERTILIZATION OF CITRUS ON FRUIT QUALITY AND GROUND WATER NITRATE-POLLUTION POTENTIAL

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Additional index words. Foliar fertilization, leaching fractions, leaf analysis, nutritional interrelations, yield.

Abstract. **Within the ranges of plant nutrient levels that sustain fruit yield, only N, P and K have important commercial effects on fruit quality. All citrus cultivars do not respond uniformly to N, P and K. Proper use of leaf analysis has proven to be a very useful guide for monitoring potential fruit quality and yield effects.**

For Valencia orange the important effects associated with an increase in N leaf level are a reduction in fruit size, juice % and ascorbic acid, and an increase in peel thickness, coarseness of peel texture and amount of green color on peel at harvest time. An increase in P is associated with a slight decrease in fruit size, peel thickness, and solids, total acids and ascorbic acid in juice, and a decrease in coarseness of peel texture and time to reach maturity. An increase in K is associated with an increase in peel thickness, coarseness of peel texture and time to reach maturity, and a decrease in creasing and juice %.

For Washington navel orange the important N, P and K effects are similar to those of Valencia except for green color on peel at harvest. Washington navel in California matures in winter and fruit color is normally not a problem.

For lemons N and P have had little effect on fruit quality. An increase in K increases fruit size, juice %, acid and ascorbic acid in juice and amount of total acid in fresh fruit, and decreases peel thickness.

Research to date showed practically no increase in NO_3-pollution potential of ground waters associated with foliar applications of urea or N low rates applied to the soil. An increase above about 100 kg N per ha annually applied to the soil increased the pollution potential.

Citrus growers apply fertilizers primarily to maintain production. Too frequently, fertilizer effects on fruit quality and size are not considered. Societal concern about pollution from fertilizer has developed. This report shows some of the effects that can occur from improper use of fertilizers and gives some guides for proper use.

Fertilizer and Fruit Quality

The general influence of fertilizers on fruit size and quality have been well documented (5, 6, 13, 15, 16, 17, 27, 28, 29). Within the range of nutrient levels for maximum production only N, P and K have important influences on quality and size. When dealing with the effects of one element on one factor of fruit quality, the solution to the problem appears simple. However, when dealing with the effects of the three nutrients on the many factors of quality, simultaneously, the integration of all the effects is more complicated. Effects on fruit quality should not be considered independently of the effects on fruit yield. Maximum or nearly maximum nutritionally attainable yield is essential in any successful citrus endeavor.

Leaf analysis guides like those in Table 1 have been used. Such guides, however, are based primarily on fruit yield. It is difficult, if not impossible, to clearly integrate the numerous effects of nutrients on fruit size and quality into such a table. The effects on yield, size and quality cannot be integrated into one range of guide numbers. Results from leaf analysis can be used most effectively if one is aware of the specific effects on fruit yield, size and quality as illustrated in Figs. 1 to 4. Tradeoffs among factors may be necessary to obtain best overall practical results. With a knowledge of the specific problems in the orchard in question, records of past fertilizer application and of past and current leaf analyses, one can plan a fertilizer program for a specific orchard.

The guides herein reported were calibrated against the concentration of the nutrients in question in 5- to 7-month old, spring-cycle leaves from nonfruiting shoots on mature trees in experiments in commercial orchards.

Nitrogen

Among the factors in Fig. 1, the amount of green color on fruit for fresh market is probably the most important commercial quality factor for Valencia orange. In California, this color factor, regreening, is less important for navels which ripen in the winter. Climate has a strong influence on regreening. With the Valencia there are 'good' and 'bad' color years, climatically. Within the climatic effects there are effects of N on regreening. Because of our inability to predict 'good' or 'bad' color years in advance, one must treat each year as though it will be a 'bad' color year, climatically. In 'bad' color years, N effects on regreening are important. In 'good' color years N effects on regreening are less important. An increase in N in the leaves is associated with an increase in regreening. Not shown in Fig. 1 is the fact that summer applications of N are associated with more regreening than winter or early spring applications.

Small fruit size, a common problem with Valencia is aggravated by high N. Rind staining of navels, a problem that develops after the fruit is packed and is of particular concern in the San Joaquin Valley of California, is intensified by high N. Other factors that are adversely affected by increasing N levels are peel thickness, coarseness of peel texture, juice %, time-to-color-break, and vitamin C content in the juice. By increasing N in the lower part of the N range for maximum production, the incidence of the peel problem, creasing, may be reduced. Thus, usually one should strive for an N level in the lower part of the range for maximum production. A major exception to the guide values (Fig. 1) occurs in areas where B and S toxicities exist. In such cases, B and S accumulation in leaves results in premature defoliation and yield loss. Increasing leaf N above 2.6% can

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Table 1. Leaf analysis guide for diagnosing nutrient status of mature Valencia and navel orange trees.[z]

Element	Unit (total in dry manner)	Deficient	Ranges[y] Low	Optimum	High	Excess
N	%	<2.2	2.2 to 2.3	2.4 to 2.6	2.7 to 2.8	>2.8
P	%	<0.09	0.09 to 0.11	0.12 to 0.16	0.17 to 0.29	>0.30
K[x]	%	<0.40	0.40 to 0.69	0.70 to 1.09	1.10 to 2.00	>2.30?
Ca	%	<1.6?	1.6 to 2.9	3.0 to 5.5	5.6 to 6.9	>7.0?
Mg	%	<0.16	0.16 to 0.25	0.26 to 0.6	0.7 to 1.1	>1.2?
S	%	<0.14	0.14 to 0.19	0.2 to 0.3	0.4 to 0.5	>0.6
B	ppm	<21	21 to 30	31 to 100	101 to 260	>260
Fe[w]	ppm	<36	36 to 59	60 to 120	130 to 200?	>250?
Mn[w]	ppm	<16	16 to 24	25 to 200	300 to 500?	>1000?
Zn[w]	ppm	<16	16 to 24	25 to 100	110 to 200	>300
Cu[w]	ppm	<3.6	3.6 to 4.9	5 to 16	17 to 22?	>22?
Mo[v]	ppm	<0.06	0.06 to 0.09	0.10 to 3.0	4.0 to 100	>100?
Cl	%	?	?	<0.3	0.4 to 0.6	>0.7
Na	%	?	?	<0.16	0.17 to 0.24	>0.25
Li	ppm	[u]	—	<3	3 to 35?	>35?
As	ppm	[u]	—	<1	1 to 5	>5?
F[v]	ppm	[u]	—	<1 to 20	25 to 100	>100

[z]With the exception of N values this guide can be applied for grapefruit, lemon and probably other commercial citrus varieties.
[y]Based on concentration of elements in five- to seven-month-old, terminal, spring-cycle leaves from nonfruiting and nonflushing shoots. Leaves selected for analysis should be free of obvious tipburn, insect or disease injury, mechanical damage, etc., and from trees that are not visibly affected by disease or other injury.
[x]Potassium ranges are for effects on number of fruit per tree.
[w]These standards are not applicable for leaves that have been sprayed or dusted with the particular element in question. Leaves that have been sprayed or dusted with Fe, Mn, Zn or Cu may analyze high or excessive in these respective elements, but in the case of Fe, Mn or Zn the next growth cycle that appears may have values in the deficient range.
[v]From fruiting shoots (5).
[u]These elements are not known to be essential for growth of citrus.

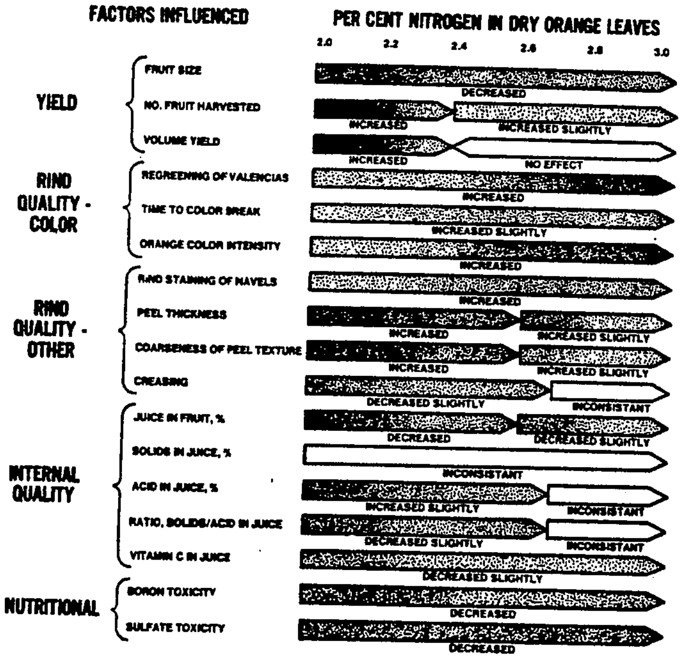

Fig. 1. Influences on yield, quality, and B and S nutrition resulting from changes in the percentage of N in 5- to 7-month-old, spring-cycle orange leaves. The greater the intensity of stippling, the greater the effect on the factor indicated. Source: (15).

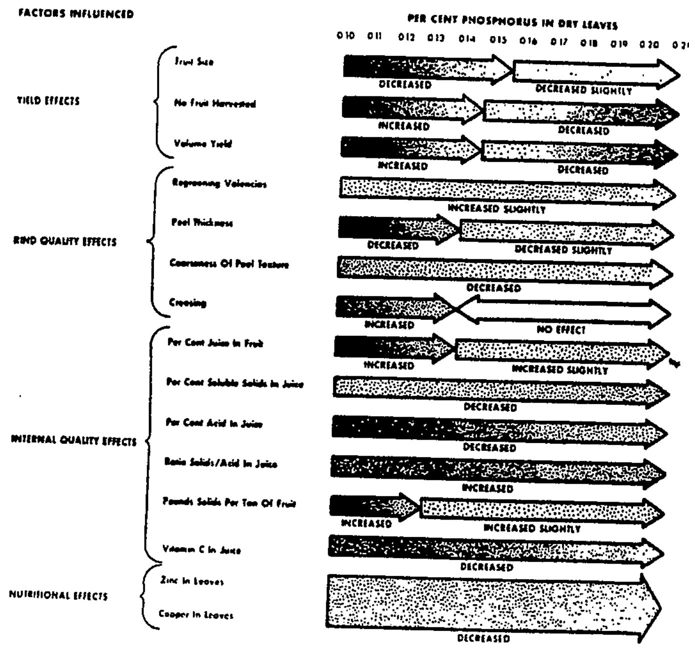

Fig. 2. Influences on yield, quality, and Zn and Cu nutrition resulting from changes in the percentage of P in 5- to 7-month-old spring-cycle orange leaves. The greater the intensity of stippling, the greater the effect on the factor indicated. Source: (15).

increase volume yield by reducing the accumulation of B and S in the leaves, and thus reducing premature defoliation. While elevated-N level adversely affects fruit quality, this sacrifice appears to be justified if yields are to be maintained under these specific conditions (22).

Nitrogen effects on grapefruit quality are similar but of a lesser degree than those on the orange. Lemon fruit quality is insensitive to N nutrition (21).

Phosphorus

In general, the impact of P on quality factors within the range of maximum production is not as great as that for N. An increase in P is associated with some reduction in fruit size, peel thickness, and coarseness of peel texture, and an increase in juice % and regreening (Fig. 2); solids and acid in the juice are decreased, but the ratio of solids to acid is increased. The latter effect could be of importance where early maturity is desired.

Little data are available on P effects on California grapefruit quality, but other data (3, 20) suggest responses similar to those for the orange. Varying P levels has had no practical effect on lemon fruit quality, even in the deficient range for yield (14).

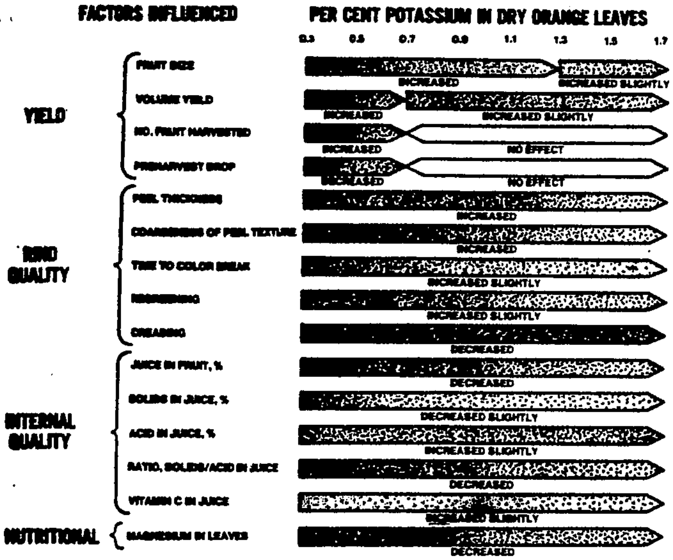

Fig. 3. Influences on yield, quality, and Mg nutrition resulting from changes in the percentage of K in 5- to 7-month-old, spring-cycle orange leaves. The greater the intensity of stippling, the greater the effect on the factor indicated. Source: (15).

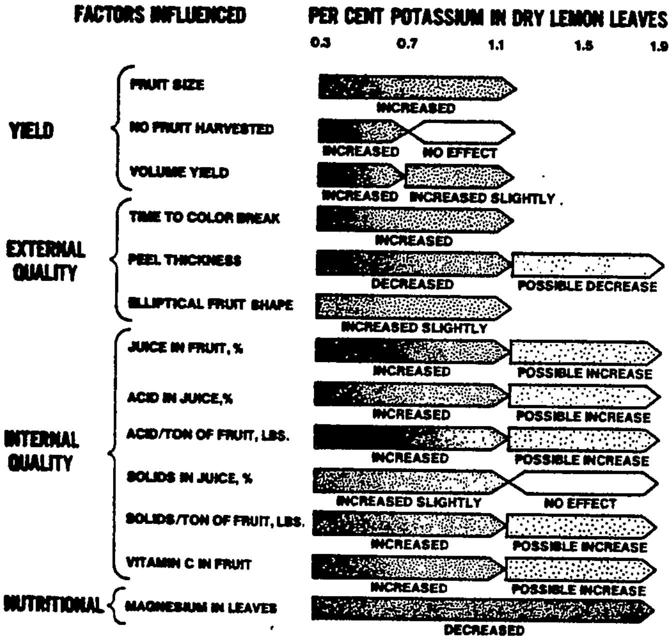

Fig. 4. Influence on yield, quality and Mg nutrition resulting from changes in the percentage of K in 5- to 7-month-old, spring-cycle lemon leaves. Absence of arrow indicates no valid data. The greater the intensity of stippling the greater the effect on the factor indicated. Source: (15).

Potassium

Most of the effects of K on orange fruit quality are unfavorable (Fig. 3). In general, K need not be much above 0.7% in the leaves except when small fruit or creasing or both are problems. To date, the most effective mineral nutrition method of reducing the incidence of creasing is to increase the K level in leaves. Soil applications of K are frequently not effective in increasing leaf K. We therefore, in these cases, resort to foliar sprays of KNO_3 which are effective. The increases in N and K in leaves with use of these sprays accentuates the regreening problem while reducing the incidence of creasing. Past research (11) and current unpublished data show that gibberellic acid sprays reduce creasing and when applied with KNO_3 sprays the results are additive. By proper timing of sprays the amount of green color on fruit at harvest can be minimized while reducing creasing. Gibberellic acid sprays are not currently registered for use on Valencia orange in California but may be in the future.

The effects of K nutrition on grapefruit quality are similar to those on the orange (10).

Practically all the effects of increasing K leaf levels in lemons are favorable for fresh or processing fruit (Fig. 4). Fruit yield, size and some of the quality effects associated with an increase in K in leaves are similar to those for orange and grapefruit, but the economic impact of the fruit quality effects is not the same. For example, a delay in time-to-color-break of the orange may not be desirable or may be of little consequence; however, a delay in time-to-color-break of lemon permits the fruit to remain on the tree longer and attain a larger size before harvest. Also, an increase in acid concentration in lemon juice is usually desirable, particularly for processing fruit; in the orange an increase in acid concentration delays the time to attain legal maturity.

Some lemon and orange quality factors are affected in opposite directions by an elevation in the K level. An increase in K level increases orange peel thickness and reduces orange juice %, while it decreases lemon peel thickness and increases lemon juice % (7). The increase in juice % and acid concentration in the juice results in a marked increase in the amount of acid per ton of fresh lemon fruit. This is of particular advantage in fruit for processing.

How to Use Guides

The guides herein reported are for 5- to 7-month old, spring-cycle leaves from nonfruiting shoots. The guides are not calibrated for leaves from behind fruit, or for other ages of leaves from nonfruiting shoots. There is a definite difference in nutrient levels between leaves from behind fruit and nonfruiting shoots (12, 19).

For most effective use of guides, one must know the nutritionally affectible problems in the orchard in question, and have records of past fertilizer applications and past and current leaf analyses. Study the charts and determine the most likely approach to minimize the problem in question. Make fertilizer adjustments accordingly. Any substantial fertilizer adjustment for one nutrient may influence the levels of other nutrients. Thus, resample the next year and make necessary adjustments. After controlling the most important problem, attack the next most important problem.

Likely effects of increasing the level of one nutrient on the level of other nutrients are summarized in Table 2. For example, an increase in the level of P in the leaves usually reduces N leaf levels. With P deficiency, N accumulates to very high levels in the leaves. Correction of P deficiency reduces N leaf levels markedly.

Other interrelations among elements have practical implications. A K deficiency is sometimes associated with a high Mg level. Potassium applications can induce or aggravate Mg deficiency. An increase in N level may increase the Mg leaf level, and will usually reduce the concentration of B and S in the leaves. An increase in P may induce or aggravate Zn or Cu deficiencies.

Calcium accumulates in leaves up to about 6 months of age. In areas where Ca deficiency does not occur, as in California, the Ca level can indicate leaf age. Less than 3.0 to 3.5% Ca would indicate leaves less than 5 months old.

Many factors influence the levels of nutrient in trees. Leaf analysis integrates the effects of these many factors into one useful number—the concentration of the nutrient in the leaves. This value provides a very useful and practical guide

Table 2. The general effect of an increase in the concentration of elements in citrus leaves upon the concentration of other elements.[a]

Element increased in leaves	Direction of influence from an increase in element in first column[y]															
	N	P	K	Ca	Mg	S	B	Fe	Mn	Zn	Cu	Mo	Cl	Na	Li	As
N	+	−	−	+[x]	+	−	−[x]	0	0[x]	0[x]	0[x]	?	?	?	?	?
P	−[x]	+	−	+	+[x]	?	−[x]	0	+	−[x]	−	?	?	0	?	?
K	−	0	+	−	−	?	+[x]	?	−[x]	0	0	?	?	?	?	?
Ca	+	0	−	+	−	?	?	?	?	?	?	?	?	?	?	?
Mg	0	0	−	−	+	?	0	?	+	+	−	?	?	?	?	?
S	−	−	−	+	−	+	?	?	?	?	?	?	?	−	?	?
B	0	−	+	−	−	0	+	?	−	0	0	?	?	?	?	?
Fe	?	−	+	+	?	?	?	+	?	?	?	?	?	?	?	?
Mn	0	0	0[x]	0	−	?	0	0	+	0	−	?	?	?	?	?
Zn	0	0	+	−	−	?	0	0	0[x]	+	−	?	?	?	?	?
Cu	0	0	+	0	0	?	0	?	−	−	+	?	?	?	?	?
Mo	?	?	?	?	?	?	?	?	?	?	?	+	?	?	?	?
Cl	?	?	?	?	?	?	?	?	?	?	?	?	+	?	?	?
Na	?	?	?	?	?	?	?	?	?	?	?	?	?	+	?	?
Li	?	?	?	?	?	?	?	?	?	?	?	?	?	?	+	?
As	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	+

[a]Source: (13). Adapted from Chapman (4) who reported upon the effects of a deficiency of an element upon the concentration of other elements in the leaves, and Smith (28) who reported for Florida conditions upon the effects of an added element upon the concentration of other elements when no elements were known to be deficient. The present authors adapted the table to include their California findings, including some where deficiencies existed.

[y]? = uncertain or unknown response; + = increase in concentration in the leaf; — = decrease in concentration in the leaf; 0 = no consistent effect.
[x]Different response than reported by Smith (28).

in planning fertilizer programs to maintain yield of fruit of desirable size and quality.

Fertilizers and Ground Water Nitrate-Pollution Potential[2]

During the past three decades, our research has been directed toward improving the efficiency of N fertilizer management to achieve high fruit yield with favorable fruit size and quality (13, 17). Leaf analysis as a guide to fertilization was developed to the point that it was widely used by the citrus industry in California. Commercial adoption of this tool reduced N usage by 50% or more and substantially decreased the NO_3-pollution potential before public concern became great (9).

In many areas in California, NO_3-N concentrations in ground waters were in excess of the limit of 10 ppm recommended by the U.S. Public Health Service Drinking Water Standards of 1962 and there was an increase in concentration with time (1, 2, 18, 24). Public concern developed; agricultural fertilizer programs were implicated.

A considerable amount of research has been devoted to this problem (26). It was concluded that mass emission of NO_3 from root zones was a better parameter than concentration of NO_3 in soil water below root zones to use in attacking this problem. In general, data show that mass emission can be reduced by reducing the drainage volume, fertilizer input, or both (23).

In 1970, we initiated a project to develop citrus fertilizer management programs that would reduce the NO_3-pollution potential without adverse effects on fruit yield, size and quality. To date, data are available from two experiments that have different cultivars, soil drainage characteristics and cultural methods.

Results with Washington Navel Orange

Irrigation water in this experiment contained about 30 ppm TDS. Leaching for salinity control was not necessary. During the five-year experimental period, leaching fractions in this sprinkler-irrigated orchard were generally less than 0.05 (8).

The concentration of NO_3-N in saturation extracts from the soil (Fig. 5) were lower for foliar-applied N than for soil-applied N. Although the high foliar-applied N rate was about twice that of the low foliar-applied N rate, there was no difference in NO_3-N concentration. In the low foliar-applied N rate, no N was permitted to reach the soil at the time of spraying. These data lead us to believe that the values for the spray treatments were background levels and would have been the same if no N had been applied during the experimental period.

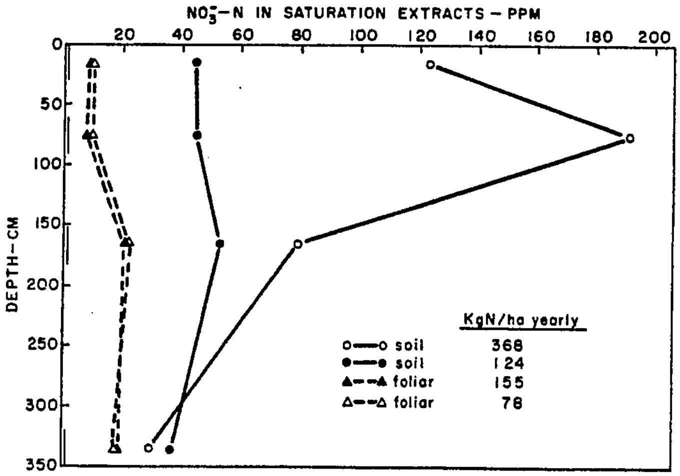

Fig. 5. Nitrate-N in saturation extracts from the soil. [Nitrogen in the Environment, Vol. 1, p. 288, 1978. Reprinted with permission of Academic Press, Inc., New York.]

Leachable N is shown in Fig. 6. Mean values for eight sampling dates for the soil-applied N rates of 368 and 124 kg and the foliar-applied N rates of 155 and 78 kg per ha were, respectively, 57.9, 17.5, 10.5 and 13.8 kg N per ha yearly. A significant increase in leachable N was found only at the 368 kg soil-applied N rate.

The relationships between leaf N level and factors of

[2]Research supporting this section was partially supported by the KEARNEY FOUNDATION OF SOIL SCIENCE, University of California, and by the OFFICE OF WATER RESEARCH AND TECHNOLOGY, USDI, under the allotment program of Public Law 88-379, as amended, and by the University of California, Water Resources Center, as a part of Office of Water Research and Technology No. A-057-CAL and Water Resources Project UCAL-WRC-W-500.

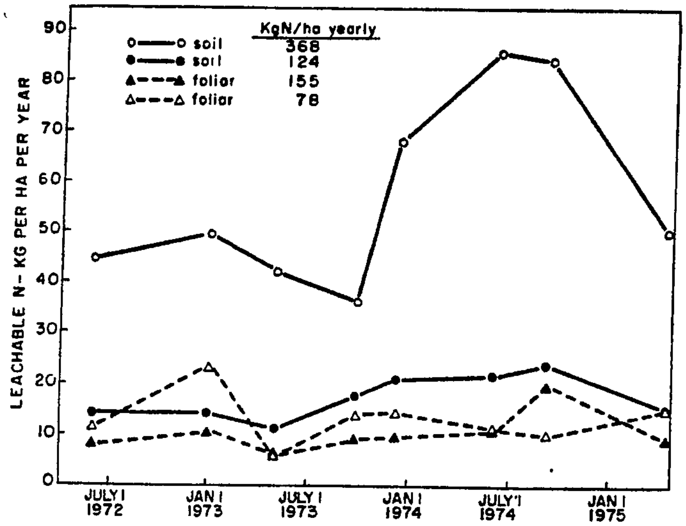

Fig. 6. Leachable N calculated from samples from below the root zone. Means for depths of 152 to 183 and 320 to 351 cm. [Nitrogen in the Environment, Vol. 1, p. 290, 1978. Reprinted with permission of Academic Press, Inc., New York.]

yield, fruit size and fruit quality occurred in a predictable manner as indicated in Fig. 1. However, the N rate required to attain adequate levels of leaf N were greater in this experiment than in previous experiments, including those with navel orange. This requirement for high N rate may be associated with the moderate wilt commonly observed before summer irrigations. In the dry soil, mass movement of NO_3 ions in soil water moving to root surfaces was likely restricted.

Results with Vigorous Lemons

The soil in the experimental orchard had good internal drainage conditions. The irrigation water contained slightly more than 1000 ppm TDS. Leaching fractions in this furrow-irrigated orchard averaged about 0.40 (25).

Profile distribution of NO_3-N concentration in saturation extracts is presented in Fig. 7 for 1976, four years after initiating the experiment. By this time, NO_3 concentration had approached steady-state conditions. Increasing soil-applied N rates increased NO_3-N concentration in the soil profile, including depths below the root zone. However, NO_3-N concentration and distributions in the profile were practically the same for foliar-applied rate of 142 kg N and soil-applied rate of 60 kg N per ha yearly. As in the navel orange experiment, we believe these are background levels of NO_3-N and would have been similar if no N had been applied during the experimental period.

Amounts of leached N are shown in Fig. 8. Effects of rates of N segregated early in the experimental period but improved slightly with time as steady-state conditions were approached. The 142 kg N foliar-applied rate and the 60 kg soil-applied rate were in the same population and were lower than higher rates of N applied to the soil. The increase in NO_3-pollution potential associated with the 167 and 488 annual soil-applied N rates was substantial.

Other than a lower concentration of ascorbic acid in the juice associated with the foliar-applied N and 488 kg soil-applied N rate, there was no significant effect of N treatments on fruit quality. Highest fruit production was associated with foliar-applied N.

Present Indications

Research to date suggests that the No_3^- pollution potential could be reduced without adversely affecting fruit

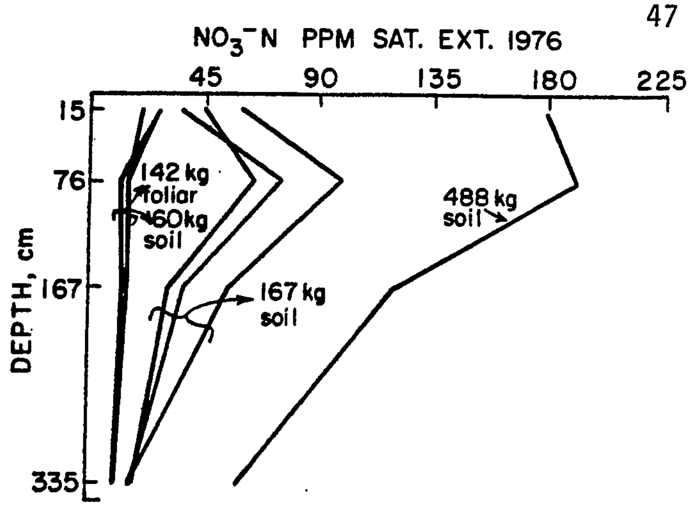

Fig. 7. Effects of method and rate of N application on distribution of NO_3-N concentrations in saturation extracts in 1976, four years after initiation of the experiment. Source: (25).

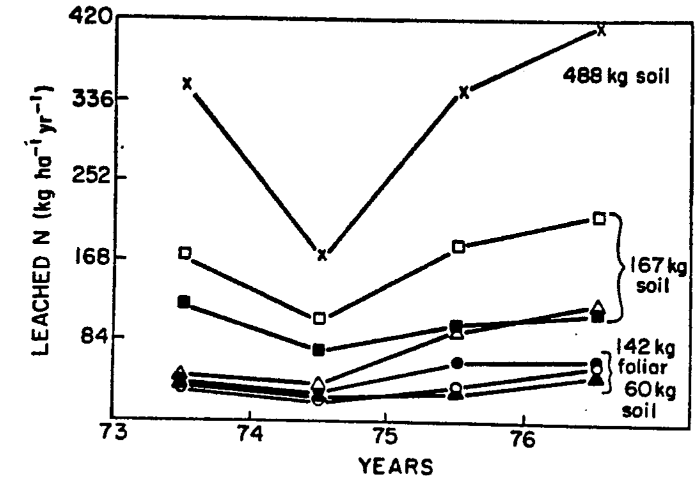

Fig. 8. Effects of method and rate of N application on leached N. Source: (25).

yield, size and quality by applying part of the N to the soil and part to the foliage, in contrast to applying all the N to the soil. However, data to date compare only all soil with all spray treatments. An experiment is underway to verify the above suggestions.

Conclusions

Leaf analysis is an effective guide for citrus fertilization to maintain high yield of fruit with favorable size and quality. Its commercial use in California reduced the NO_3-pollution potential for ground water substantially. Data to date suggest a lower NO_3-pollution potential associated with part of the N applied to foliage and part to the soil, than with all N applied to the soil.

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