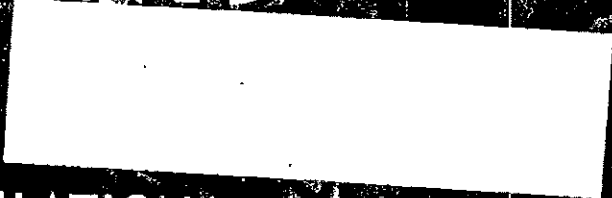


# Citrograph

November 2000

## IMPROVING QUALITY THROUGH NUTRIENTS



DFA CHANGES REGULATIONS • POST-HARVEST DISEASES

# CITROGRAPH

Volume 85 Number 10

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**Changes in Citrus Regulations Proposed** — The Department of Food and Agriculture is proposing to amend the California Code of Regulations pertaining to oranges. What are these changes and how will they affect you?

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## RESEARCH

**Improving Citrus with Foliar/Soil Nutrients** — Identifying the role of essential mineral nutrient elements in the physiology of citrus trees and applying the nutrients at the appropriate time can stimulate a specific physiological process. UC Riverside Professor of Plant Physiology Carol Lovatt concluded a four-year study addressing the questions of both how and when to fertilize for the greatest gains in yield.

*By Carol J. Lovatt*

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**Watch Out for Post-Harvest Citrus Diseases** — The Florida Department of Citrus offers tips in identifying, as well as avoiding, several harvest and post-harvest diseases which could seriously jeopardize a season of hard work.

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## CHEMICAL UPDATES

U.S. EPA names miticide-insecticide milbemectin from Gowan Company and Sankyo Co. Ltd. as reduced risk pesticide; Galigan herbicide launched for broadleaf control.

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## UPCOMING EVENTS

Over 1,000 representatives from the worldwide citrus industry are expected to attend the International Society of Citriculture Congress 2000 on Dec. 8-7 at Disneyworld's Granddahl Spring Resort.

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**Sunkist gets Global with China/Argentina** — The nation's largest citrus cooperative has globally expanded its marketing ability through separate agreements to market Argentine citrus in the United States and a recent extension of permanent normal trading relations to China.

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## PRODUCTS AND INFORMATION

Patrol wheelbarrow, urea from Carifer, Tire oil, south coast, acetic, Citofluorene, Imzebor, Dyes, juices, and leaf analysis services for citrus and avocados by Fruit Growers Laboratory, Inc.

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The goal of our research is to identify the role that the essential mineral nutrient elements play in the physiology of the citrus tree and then to apply the nutrient as a fertilizer to the foliage at the appropriate time in the phenology of the tree, i.e., a time when the demand for the nutrient is likely to be high, in order to stimulate a specific physiological process. Fruit set (early fruit drop) is the most critical stage of fruit development from the grower's point of view. It is during this period that the greatest gains in fruit retention influencing final yield can be made.

number of large commercially valuable fruit per tree – and reduced alternate bearing over the four years of the study compared to trees receiving the six small applications of nitrogen. Thus, even for soil fertilization, time of application is an important factor influencing yield and fruit quality. This is an area of fertilization that has been minimally investigated in citrus production. Soil-applied fertilizers, mulches and other amendments can be used to not only supply essential mineral nutrient elements, but also to ameliorate soil problems, eggs, salinity, soil structure,

1.32 lb N/tree. Despite this, foliar nitrogen fertilization was not widely adopted commercially. Due to the potential for ammonia toxicity, there is a limit in the amount of nitrogen that can be applied in a single application, necessitating a minimum of three annual sprays to supply the recommended rate of nitrogen. In contrast, earlier results of Sharples and Hiltrehan (1969) suggested foliar applications of urea at the appropriate time might increase yield. For seven years, yields of "Valencia" orange trees receiving only 0.51 lb N/tree split between two foliar applications of urea, one in early February and a second in late April to early May, produced yields that were statistically equal to those obtained with much higher rates (0.99 or 2.01 lb N/tree) of soil-applied ammonium nitrate. The objective of our research was to identify specific times in the phenology of the navel orange tree when a single foliar application of low-biuret urea at 0.35 lb N/tree could economically increase yield and/or fruit size compared to soil-applied nitrogen. The overall goal is to motivate growers to replace soil-applied nitrogen with foliar nitrogen fertilization to reduce the potential for groundwater nitrate pollution.

The efficacy of a single foliar application of low-biuret urea during one of three phenological stages was tested in four commercial navel orange orchards. The effect of applying urea to the canopy at pre-bloom (prior to or during flower initiation) or at full bloom was quantified with the objective of increasing fruit set and yield in Southern California orchards where yields average 12 ton/acre. Previous research in our lab provided evidence of a relationship between ammonia – a breakdown product of urea – and its metabolites, and flowering and fruit set in citrus. When stress treatments that promote flowering in citrus were reduced in duration, i.e. four instead of eight weeks of low-temperature treatment, or severity, i.e. deficit-irrigated instead of withholding irrigation, foliar-applied low-biuret urea 0.35 lb N/tree raised the tree ammonia status and increased both the number of inflorescences per tree and flowers per inflorescence, but not the number of vegetative shoots. We subsequently demonstrated that the metabolism of

## IMPROVING CITRUS WITH FOLIAR/SOIL NUTRIENTS

By Carol J. Lovatt  
University of California, Riverside

Events during this period also impact fruit size and quality.

In California, citrus flowering and fruit set, periods of high nutrient demand, occur when soil temperatures are low. Soil temperatures are generally 59 F from January to April in citrus growing areas of California. Low soil temperature reduces root metabolic activity, solubility of nutrients in the soil solution and nutrient transport in the transpiration stream. Thus, the ability of trees to utilize nutrients applied to the soil is dependent on many factors unrelated to nutrient demand. With increased use of sprinkler, drip or microjet irrigation systems, there is a growing trend to divide the annual amount of fertilizer to be applied into six to 12 small monthly applications. While this strategy reduces the potential for groundwater nitrate pollution, it ignores tree phenology and nutrient demand.

Recently, my lab completed a four-year study comparing the standard practice of splitting the annual rate of nitrogen fertilization into six small applications vs. providing double doses of nitrogen at specific times in the phenology of the tree. The research identified two key times for which the extra nitrogen simultaneously increased total kg/fruit per tree – the

pH, water-holding capacity, and to promote a pathogen-suppressive rhizosphere.

In foliar fertilization, the nutrient must be taken up by leaves of the crop, or other target organs, and be phloem mobile. Foliar fertilization with nutrients meeting these criteria is considered to be five to 30 times more efficient than soil fertilization, depending on the nutrient, crop and soil in which the crop is growing. Moreover, foliar fertilization can meet the tree's demand for a nutrient at times when soil conditions – such as low temperature, low soil moisture, pH, or salinity for example – would render soil-applied fertilizers ineffective. Optimal stages in citrus tree phenology when foliar-applied nitrogen, phosphorus, boron, or zinc, resulted in increased yield and/or fruit size and a higher ratio of total soluble solids-to-acid for "Washington" navel orange and Clementine mandarin, which are reported here.

### Use of Foliar Fertilizers in Citrus

Embleton and Jones (1974) demonstrated that regardless of the fertilization method, maximum nutritionally attainable yields for sweet oranges annually required between 0.99 and

ammonia to arginine and arginine to polyamines were linked in navel orange flowers and developing fruit and provided evidence of the role of specific polyamines in low-temperature stress-induced flowering in navel orange. Developing flowers and post-petal fruit borne on leafy inflorescences were characterized by significantly higher polyamine concentrations, faster growth rates and a greater percent of fruit set than those borne on leafless inflorescences. Foliar application of low-biuret urea at full bloom significantly increased concentrations of ammonia, arginine and polyamines and fruit growth rate and size by June for fruit of leafy inflorescences.

Last, based on the well-established role of polyamines in promoting growth by cell division and on our finding that foliar-applied urea stimulated polyamine biosynthesis, we hypothesized that a foliar application of low-biuret urea at the end of the cell division stage of fruit growth might increase the cell division rate or extend the length of the cell division period of fruit growth, and thus increase fruit size without increasing fruit set. The end of the cell division stage of fruit growth in navel orange is associated with the time the peel is at its maximum thickness. The effect of a foliar application of urea at the end of the cell division stage of fruit growth (time of maximum peel thickness) was tested with the goal of stimulating cell division to increase fruit size in two orchards in the San Joaquin Valley of California, where yields average 24 ton/acre.

### Winter Pre-bloom Foliar Nitrogen

For the three successive harvests, from 1990 through 1992, Ali and Lovatt (1994) successfully increased fruit set and yield of the "Washington" navel orange with a single foliar winter pre-bloom application of low-biuret urea. A final concentration of 0.5 percent N (as Unocal Plus, 20 percent N, and 0.1 percent biuret), provided 0.35 lb N/tree. Control trees received 1.10 lb N/tree as urea (granules, 0.25 percent biuret) applied to the soil in winter from November to January. Single foliar applications of urea were made on Nov. 15, Dec. 15, Jan. 15 or Feb. 15. The foliar applications made on Jan. 15 or Feb. 15, the approximate time of irreversible commitment to flowering and flower initiation for the Southern California orchard in

which the research was conducted, significantly increased yield all three years of the study. Applications of foliar urea made on Nov. 15 or Dec. 15 increased yield two of the three years. Yield increases were not accompanied by a decrease in fruit size. As the total weight of fruit per tree increased in response to foliar-applied urea, the number of fruit of commercially valuable size also increased. Yield increases were not due to improved nitrogen status of trees receiving a foliar application of low-biuret urea. All trees had optimum levels of N and other nutrients throughout the experiment according to annual September leaf analyses. There was no significant relationship between tree nitrogen status and yield. Time of foliar urea application significantly affected cumulative yield. In each year of this study, the winter pre-bloom foliar application of low-biuret urea was cost-effective. January or February foliar-applied urea resulted in net cumulative increases over three years in yield over the control of 8.3 and 6.6 ton/acre, respectively.

### Full Bloom Foliar Nitrogen

At full bloom low-biuret urea (as Unocal Plus, 20 percent N, 0.1 percent biuret) was applied to fully cover the canopy of "Washington" navel orange trees at a final concentration of 1.3 percent N, providing 0.35 lb N/tree. All trees had optimum levels of N and other nutrients throughout the experiment according to annual September leaf analyses. The treatment significantly increased both total weight and number of fruit per tree in the "on" year, but not in the "off" year. Combining the full bloom application of urea with an application of cytokinin (proprietary material) at full bloom and 30 days later significantly increased total weight fruit per tree both years of the study. As yield increased so did the number of commercially valuable large-size fruit with a transverse diameter of 2.8 to 3.1 inches. The two treatments resulted in a net increase in cumulative yield over two years over the control of 2.8 and 4.4 ton/acre, respectively. Both treatments were cost-effective.

### End of Cell Division Stage of Fruit Growth

Approximately one week or three weeks past petal fall, low-biuret urea (as

Unocal Plus, 20 percent N, 0.1 percent biuret) was applied to provide full coverage of "Frost nucellar" navel orange trees at a final concentration of 1.5 percent N to provide 0.35 lb N/tree. Both treatments significantly increased the number of large-size fruit with a transverse diameter of 3.2 to 3.5 inches in a single, but different, year of the three year study. In an attempt to improve the efficacy of the treatment, the time of maximum peel thickness, which marks the end of the cell division stage period for navel oranges, was determined experimentally for orchards from southern coastal California to the northern citrus region of the San Joaquin Valley for both "on" and "off" crop years. Maximum peel thickness occurred between June 17 and July 27. Based on this result, low-biuret urea (granules, 46 percent N, 0.25 percent biuret) was applied to "Frost nucellar" navel orange trees at a final concentration of 1.5 percent N to provide 0.35 lb N/tree during mid-May or mid-July. This study included phosphorus, another nutrient that would be in high demand during cell division, and, a nutrient known to increase fruit quality by increasing soluble solids per hectare and the ratio of total soluble solids to acid in the juice. Phosphorus was applied to the foliage as potassium phosphite (Nutri-Phite, 0-28-26) at a rate of 0.64 gal/acre in mid-May or mid-July, or as two applications at 0.49 gal/acre in mid-May and mid-July. All trees had optimum nutrient concentrations according to annual September leaf analyses. The July application of urea and the double application of potassium phosphite in May and July were the only treatments that significantly increased the number of commercially valuable large-size fruit with a transverse diameter of 2.7-2.9 inches, 3.0-3.1 inches, and 3.2-3.5 inches for packing carton sizes 88, 72 and 56, respectively. In addition, these two treatments had higher total weight (non-significant) and number of fruit per tree. The double-application of potassium phosphite also significantly increased total soluble solids and the ratio of total soluble solids to acid by early November compared to control fruit. By this date, fruit from trees receiving the two foliar applications of potassium phosphite had a ratio of 8.1 compared to a ratio of 7.2 for control fruit. A minimum ratio of 8.0 is required for navel harvest in California. Total soluble solids and the ratio of total soluble solids to acid remained significantly higher in fruit

*Continued on Page 8*

## Improving Citrus

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from trees treated with potassium phosphite than control fruit 30 days later.

Similar results were obtained in the second year of the field study, with the July application of urea and the double application of potassium phosphite in May and July producing the highest number of commercially valuable large-size fruit with a transverse diameter 2.7-2.9 inches, 3.0-3.1 inches, and 3.2-3.5 inches for packing carton sizes 88, 72 and 56, respectively. In the second year and for the two-year cumulative yield, the increase in the number of large size fruit was significantly higher than the control for only the phosphite treatment.

## Increasing Mandarin Flowering Fruit Set Size and Quality

To determine if these treatments would also be effective in mandarin production, I have been testing foliar fertilizer and plant growth regulator treatments on two Clementine mandarin varieties in two cit-

rus growing areas of Morocco in collaboration with Dr. Mohamed El Ohnani. The two years of yield data that we have as part of a four-year study documented for mandarins that a winter pre-bloom foliar application of urea (1 percent) increased flower number, kg fruit per tree and the number of large export quality fruit. We also learned that a foliar application of urea (1 percent) two weeks before maximum peel thickness increased the number of large export quality fruit without a significant reduction in kg fruit per tree. Foliar-applied urea (1 percent) combined with benzyladenine (25 ppm), a commercial cytokinin (Accel from Abbott Laboratories) or with 2,4-D (20 ppm), or potassium nitrate (5 percent) combined with 2,4-D (20 ppm) were equally effective as urea alone. All treatments had positive or no effect on fruit quality. However, the high cost of the PGRs makes these treatments more expensive to obtain the same results obtained with urea alone. Another successful but expensive treatment was multiple foliar applications of GA<sub>3</sub> (15 ppm each application, ProGibb) at the matchhead stage of flower bud development, 10 percent anthesis, 75 percent petal fall and two

weeks before maximum peel thickness. The effect of this treatment on post-harvest fruit quality needs to be evaluated further.

## Conclusion

Winter and spring foliar fertilizer applications likely increase fruit set and yield because nutrients essential for flowering and fruit set are limiting due to reduced transpiration and/or nutrient acquisition by roots when air and/or soil temperatures are low. The key has been, however, to identify the specific nutrient elements to be applied and the role each plays in fruit set and development in order to determine the optimal time to apply the nutrient to stimulate a specific physiological process. Our previous research provided evidence that foliar urea applied during or after a low-temperature or water-deficit period increased citrus flowering by elevating the ammonia status of the tree and increased the polyamine content, growth rate, and size of developing citrus fruit, as well as their potential to set. The mechanism by which fruit size was increased by foliar application of urea or potassium phosphite at the end of the cell division stage of fruit growth (identified by maximum thickness of peel) remains to be determined. The increased ratio of total soluble solids to acid in juice of fruit from trees treated with foliar sprays of potassium phosphite is the reported response of citrus fruit to increased phosphorus nutrition. The results of our research identified three stages in the phenology of the citrus tree when foliar applied urea-N can be used to increase yield or fruit size. In general, low-biuret urea applied during the period from flower initiation through fruit set significantly increased yield without reducing fruit size, whereas applications made at the end of the cell division stage of fruit development (time of maximum peel thickness, mid-June through end of July in California) significantly increased fruit size without affecting yield. Each foliar urea application provided 25 to 33 percent of the annual N required by sweet oranges for maximum yield. The treatments were cost-effective and reduced the potential for nitrate pollution of the groundwater. □

*Carol J. Lovatt is a Professor of Plant Physiology with the Department of Botany and Plant Sciences at the University of California, Riverside.*

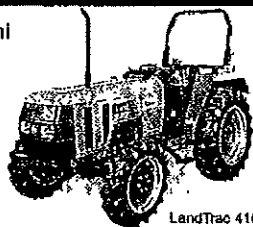
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