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Foliar Urea Increases Citrus Yields

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Introduction

Citrus trees flower in response to low temperatures experienced during the winter. Research has shown that flower number is consistently correlated with the duration of the low-temperature period. It has been found that the ammonia content of the leaves increases during the period of low temperatures. Basic research suggested that winter foliar applications of low biuret urea (LBU) could increase flowering. Three years of field research confirmed that winter foliar applications of LBU increased orange yields without reducing fruit size. Unocal Plus® was used as the source of LBU since it has the lowest biuret content now available.

Citrus trees flower in response to low temperatures experienced during the winter.

Basic research

Citrus trees flower in response to low temperatures experienced during the winter. Controlled-environment chambers have been used to apply low temperatures in a quantitative manner so that changes in plant growth regulators, carbohydrates and nitrogen compounds could be monitored in relation to floral intensity. The results showed that only the ammonia level in the leaves could be correlated with low temperatures and floral intensity. There was no correlation between the leaf concentration of total nitrogen or nitrate; the effect on flowering is specifically related to the increased ammonia concentration.

The ammonia status of citrus leaves can be artificially increased through the foliar application of urea. Because of the well-known adverse effects of biuret, LBU is recommended for use on citrus. We used Unocal Plus in our research.

We were able to increase both the ammonia concentration and flower number of five-year-old "Washington" navel orange trees by spraying them with LBU. Trees were subjected to short periods of cold treatment which would result in minimal flowering and then sprayed with LBU (Table 1). Note the correlation between the increased ammonia content and the increased flower number.

Because of the well-known adverse effects of biuret, low biuret urea is recommended for use on citrus.

In addition to increasing the flower number, the foliar application of LBU also increased the proportion of flowers borne on leafy inflores-

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Table 1
Leaf ammonia content and flower number increased when sprayed with LBU.

Weeks of low-temperature treatment	Increase in leaf ammonia content	Increase in flower number
	-----%-----	-----%-----
4	166	194
6	215	230

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cences (shoots bearing leaves and flowers). The foliar application of LBU following a 6 week low-temperature period doubled the number of leafless inflorescences but the number of leafy inflorencences increased four-fold (Table 2). In addition, the flowers borne on leafy inflorescences increased from 25 to 40 percent of the total flowers. Moreover, foliar LBU resulted in a three-fold increase in the number of leaves per inflorescence.

The increase in leafy inflorescences and number of leaves is important because leafy inflorescences set proportionately more fruit that persist to harvest than do leafless inflorescences.

We were able to increase both the ammonia concentration and flower number of 5-year-old "Washington" navel orange trees by spraying them with low biuret urea.

This research was conducted on five-year-old rooted cuttings of "Washington" navel orange in controlled temperature chambers where we could closely control and monitor growing conditions.

Field Research

We wanted to determine whether similar results could be obtained under field conditions. We used commercially producing 30-year-old "Washington" navel orange trees. LBU was foliar applied at the equivalent of 28 lbs. of nitrogen per acre on either November 14, December 14, January 14, or February 14.

All trees also received 110 lbs. of nitrogen per acre as LBU applied to the soil each year in either November of December to ensure that adequate nitrogen was available.

Table 2
Foliar LBU increases leafy inflorescences.

Treatment	Flowers on leafless Inflorescences	Flowers on leafy Inflorescences	Leaves on leafy Inflorescences
No LBU	290	110	136
Foliar LBU	615	406	499

For three consecutive years, a winter foliar application of LBU in January or February increased both the fruit weight per tree and the number of fruit per tree. A January or February foliar application of LBU increased yield by just over one carton (37.5 lbs.) per tree in 1989-90, just under one carton per tree in 1990-91, and by 2.5 cartons per tree in 1991-92. Smaller and less consistent yield increases resulted from applications made in November or December. January or February applications are preferred because they have consistently increased yields.

It is important to stress that there was no reduction in fruit size as a result of this yield increase. For1989-90 and 1990-91, the application of LBU had the greatest effect on fruit in carton sizes 88 and 72. There was an additional carton per tree in 1989-90 and in additional half carton per tree in 1990-91.

The yield increase resulting from the winter foliar application of LBU was not due to improved nitrogen status of the trees. There was no difference in leaf nitrogen concentration for trees receiving foliar LBU or soil applied LBU. Total leaf nitrogen was between 2.5 and 2.6% and there was no correlation between total leaf nitrogen and yield.

The yield increase resulting from the winter foliar application of low biuret urea was not due to improved nitrogen status of the trees.

A winter foliar application of low biuret urea in January or February increased both the fruit weight per tree and the number of fruit per tree.

The winter foliar application of LBU is a profitable practice. We conducted a cost benefit analysis using the following values: (1) The 1989-90 average price of $3.20 per carton, (2) the average cost of 15 gallons of Unocal Plus per acre, (3) spray rig at $25.00 per acre for the highest cost per care and (4) airplane at $10.00 per acre to give upper and lower range reported as net return in Tables 3 and 4.

It is important to stress that the values reported in Tables 3 and 4 are the *increases* in yield and economic return due to the winter application of LBU compared to the standard grower practices. The values are cumulative totals over the three years of the study.

This analysis underestimates total and net return because it does not take into account the increased fruit in carton sizes 72 and 88. Also keep in mind that yields were greatly reduced in the 1990-91 season due to the freeze in December of 1990.

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Table 3
Three-year net cumulative increase due to foliar LBU.

	Date LBU applied to the foliage			
	November	December	January	February
Increased # of packing cartons	288	319	452	400
Increased total return	$924	$1024	$1451	$1284
Increased net return	$814-845	$914-945	$1341-1372	$1172-1205

Table 4
Average increased net dollar return per acre per year for trees receiving foliar LBU versus soil LBU

Date LBU applied to the foliage			
November	December	January	February
$271-282	$305-315	$447-457	$391-402

Summary

Foliar application of LBU can increase the ammonia concentration in citrus leaves which leads to increased flower numbers. In addition, there are more leafy inflorescences and more leaves per inflorescence. This effect is due to increased ammonia concentration and not improved nitrogen status. These leafy inflorescences are known to make a disproportionately higher contribution to total yield. Foliar application of LBU in the winter increased the yield of 30-year old "Washington" navel oranges and was profitable in all three years of the study. There was no decrease in fruit size due to the increased yield.

The research leading to this report was supported by the University of California Water Resources Center, by matching funds from the Citrus Research Board, the Citrus Research Center and Agricultural Experiment Station of the UC Riverside.

Unocal Plus®

Dr. Steven E. Petrie

Unocal Plus is the name for Unocal's Premium Liquid Urea Solution (20-0-0). Unocal Plus is the preferred source for foliar applications of nitrogen to crops. Foliar applications of nitrogen increase nutrient uptake efficiency compared to soil applications and reduce the potential for nitrogen losses.

Unocal Plus is specially formulated to reduce the potential for phytotoxicity from biuret and free ammonia.

Foliar applications of nitrogen increase nutrient uptake efficiency compared to soil applications and reduce the potential for nitrogen losses.

Biuret is a common constituent of urea; it is formed during manufacturing and is of little concern when the urea is used for soil applications. Soil microorganisms break down the biuret and it actually supplies plant available nitrogen.

Foliar applications of biuret are another matter completely. Biuret can be phytotoxic, particularly when applied to perennial crops such as citrus and other tree crops. For sensitive crops, the general guideline is to apply as little biruet as possible.

Unocal Plus has the lowest concentration of biuret of any commonly available urea source. Typical analyses show less than 500 ppm; this is much less biuret than in common "low-biuret" urea.

Unocal Plus is also safer because the potential for free ammonia is greatly reduced. A special phosphate-based buffer is used to maintain the solution pH. Safety is further assured by the addition of a pH-sensitive dye. Should free ammonia form, the dye changes color from yellow to red indicating the presence of free ammonia.

The addition of acid based materials will lower the solution pH and restore the proper pH to eliminate free ammonia. The N-pHURIC® products from Unocal are excellent choices to lower the solution pH.

Unocal Plus is one of the safest forms of foliar nitrogen available. It is specially manufactured in a process which removes most biuret and free ammonia. It contains a buffer to minimize formation of free ammonia and a pH-sensitive dye to reveal the presence of any free ammonia which does occur. In short, Unocal Plus is the preferred source for foliar nitrogen applications.

Product Stewardship - What our Industry is Doing

Dr. Steven E. Petrie

Product stewardship will continue to be one of the "buzzwords" of the 1990's as increasing environmental pressures are brought to bear on fertilizers. What have we in the fertilizer industry been doing to foster good product stewardship? In a word - PLENTY.

Researchers, agronomists, field representatives and everyone else involved in the manufacturing, distribution, and use of fertilizers has been actively promoting good product stewardship in a wide variety of ways.

Many Best Management Practices such as soil testing, plant analysis, timely application of the appropriate amount of fertilizer and so forth have been developed with the close cooperation of private industry, Land Grant agricultural colleges, and the USDA. The wide-spread adoption and utilization of these BMP's is due in large measure to our efforts in the field, working closely with growers.

Unocal has published a general BMP guide as well as a detailed BMP booklet for wheat. We will also be publishing BMP booklets for potatoes and citrus in the future.

The Certified Crop Adviser program is being developed by the American Society of Agronomy working closely with representatives from private industry. This program will help increase the professionalism of crop advisers and demonstrate practical knowledge of environmentally sound soil management and crop production. This program has widespread support in the industry even though it will mean increased costs.

Unocal has representatives on the National Steering Committee of the CCA program as well as the California State Board and is active in the Pacific Northwest region.

In California, the fertilizer industry was the driving force behind the special fertilizer mill tax specifically targeted to establish the Fertilizer Research and Education Program (FREP). Funds generated by this tax on fertilizers are used to support research and education programs designed to improve fertilizer use and efficiency and reduce the environmental impact of fertilizers. How many other industries would have worked so hard to increase taxes on themselves?

Many new products and services are being developed specifically because they offer the opportunity for reduced environmental effects. Examples include slow release fertilizers, improved formulations for foliar applications such as Unocal Plus, and variable application rate technology.

Private industry is taking the leadership role in promoting improved product stewardship. We are working hard to improve the efficiency of our products and reduce the potential for adverse impacts on the environment. We are conducting innovative research into improved fertilizer formulations, more efficient application techniques, and other methods to increase crop yields and quality. We don't know all the answers (yet) but private industry will be a crucial part of the solution that is developed.

American Society of Agronomy Annual Meeting

Dr. Steven E. Petrie

The 1992 Annual Meeting of the American Society of Agronomy was held from November 1-6 in Minneapolis, MN. A total of over 2,700 papers were presented and over 5,000 people attended the meeting. Hundreds of papers were presented which dealt with soil fertility, fertilizer and nutrient management, soil testing to improve fertilizer recommendations and the impact, both real and potential, of fertilizers on the environment. Although exact figures are unavailable, it is clear that more papers dealt with environmental concerns than ever before. Environmental factors are becoming as important as production considerations for agriculture. Some of the meeting highlights are discussed in more detail in the following section.

> Hundreds of papers were presented which dealt with soil fertility, fertilizer and nutrient management, and soil testing to improved fertilizer recommendations

> There has been a tremendous amount of research in the corn belt during the last 7 or 8 years on soil testing for nitrogen

Soil Testing for N

Soil testing to measure available nitrogen and using this value as a guide when determining nitrogen fertilizer recommendations is a common practice in much of the western U.S. Some of the early work on this concept was conducted in the Columbia Basin in the early 1950's.

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Soil testing for nitrogen has not been used in the cornbelt of the Midwestern U.S. Measuring available soil nitrogen was thought to be of little value when a thunderstorm can dump three inches of rain in a few hours. This would readily leach the available nitrogen and greatly reduced the value of any soil test reading for nitrogen.

> We in the western U.S. do a good job of managing our fertilizer nitrogen.

Economic and environmental pressures have combined to force a new look at soil testing for nitrogen in the corn belt. There has been a tremendous amount of research in the cornbelt during the last 7 or 8 years on soil testing for nitrogen using what is called the "pre-sidedress nitrate test" or PSNT. A soil sample is collected just prior to sidedress application of nitrogen and the nitrate concentration measured and correlated with the response to sidedress nitrogen application.

Some of the studies have found that growers can reduce their standard sidedress nitrogen application rates from 50-75 lbs./A with no yield reduction.

Some of the studies have found that the PSNT can be a useful and accurate tool to predict the need for additional sidedress nitrogen. The critical level reported in the studies varies depending on many factors. There are also studies which show little correlation between the PSNT value and the response to additional sidedress nitrogen. Unfortunately, the effectiveness of the PSNT varies widely depending on soil type, rainfall patterns, soil organic matter content, overall growing conditions, and other factors not yet understood.

We in the western U.S. do a good job of managing our fertilizer nitrogen. We have a long history of soil testing for nitrogen and monitoring the nitrogen status of crops through tissue testing followed with nitrogen application as needed in the irrigation water. Nonetheless, the fact that field research shows that growers in the cornbelt can reduce their nitrogen application rates without reducing yields has caught the attention of regulatory agencies and the environmental community alike. They will undoubtedly try to apply this model to other places in the U.S.

Cover Crops

The use of fall seeded cover crops as a management tool to reduce nitrogen leaching was also a topic of some interest. Nitrogen remaining in the soil after the crop is harvested can be lost due to leaching during the fall, winter and early spring when no crop is being grown.

Research has shown that a cover crop seeded soon after crop harvest in the fall has the potential to take up nitrogen and reduce the amount of nitrogen that is available to be lost by leaching. The cover crop is incorporated into the soil prior to the establishment of the spring corp. The decomposition of the cover crop releases the nitrogen to the next crop.

> The use of cover crops may be a recommended Best Management Practice in the future

This is a straightforward concept, yet the application to production agriculture is proving difficult. Many questions remain about which species are best planted as cover crops, how to manage them for optimum growth and nitrogen uptake, when and how to take them out in preparation for the spring crop, how much nitrogen do they take up under different conditions, when is the nitrogen they take up released to the spring crop, and so on.

The use of cover crops may be a recommended Best Management Practice in the future but, at the present time, there is little accurate information to provide growers. Because of this lack of basic information, no recommendations can be made concerning the use of cover crops but research is continuing.

Site-Specific Farming

A number of papers and other presentations dealt with the concept of varying the application of production inputs (seed, fertilizer, pesticides, etc.) throughout the field to match the specific soil, pest and crop needs at a particular location within the field. This "Variable Application Rate Technology", or VART, offers the potential for greatly increased input efficiency. Inputs will be applied only where necessary and only at the rate needed to accomplish the desired goal. For example, on-board sensors will control herbicide application so that only weedy areas are sprayed, not the entire field.

> "Variable Application Rate Technology", or VART, offers the potential for greatly increased input efficiency.

VART for fertilizers is in its commercial infancy but its use is growing rapidly. Soil samples are collected on a grid pattern, the results are computerized and used to control the fertilizer application within the field. The cost of the VART equipment, including soil sampling, has been estimated at about $5-6/A above the standard application cost under Midwestern conditions. This has proven to be

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competitive with standard application technology because of the savings of not applying fertilizer where it is not needed. The price of VART in the West may be quite different because of different field sizes, equipment needs, and so forth.

Adoption of VART for fertilizers is being driven directly by the farmer's need to lower production costs through reduced fertilizer application rates where appropriate and, indirectly, by environmental consideration. The application of nutrients based on soil sampling is a recommended BMP; the use of VART permits the concept to be applied to much smaller management units than an individual field.

The ASA publishes the Agronomy Abstracts, which is a compilation of summaries of all papers presented at the meetings. Contact the ASA for more information on the papers referred to in this article.

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We now have several reprints available from past *Solution Sheet* issues. These reprints have all been updated in content, and are available from the *Solution Sheet* editor.

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Updated from articles appearing in *Solution Sheet,* vol. 2, nos. 4, 5, and 6

Potato Quality
Updated from articles appearing in *Solution Sheet,* vol. 1, no. 2, and vol. 5, nos. 7, 8, and 9

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