# Citrus Canker Control With *K-Phite*® Systemic Fungicide

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## CITRUS CANKER CONTROL BREAKTHROUGH

K-Phite's bacteriological effectiveness against citrus canker was first observed by growers, who were already using the broad spectrum, systemic, biological fungicide, for control of other citrus diseases.

Citrus experts, advisers, and Canker Task Force workers, also noted that canker was being controlled in groves where K-Phite was in use. It was also noted that where a few trees did become infected due to hurricane injury and distribution of the disease, canker not only did not spread to adjoining trees, where K-Phite was in use, but the infected trees also showed no signs of canker, after a few months, without further spread of the disease.

The bacterial plant pathogen, *Xanthomonas axonopodis* pv. *citri* (*Xac*), is the cause of Asiatic citrus canker, and typically infects plant tissue intercellularly, at a point of exposed injury, where the bacterial hyphae then attempt to probe and penetrate cell walls for nutrition in order to promote the spread of the disease throughout the plant.

K-Phite now has four known modes of action, in both preventing disease, and curing disease, after it occurs.

It was observed that in groves not treated with K-Phite, that canker was easily spread throughout the grove, especially with grove equipment, such as herbicide booms. In K-Phite treated blocks, canker did not spread, although an individual tree may have become inoculated with canker.

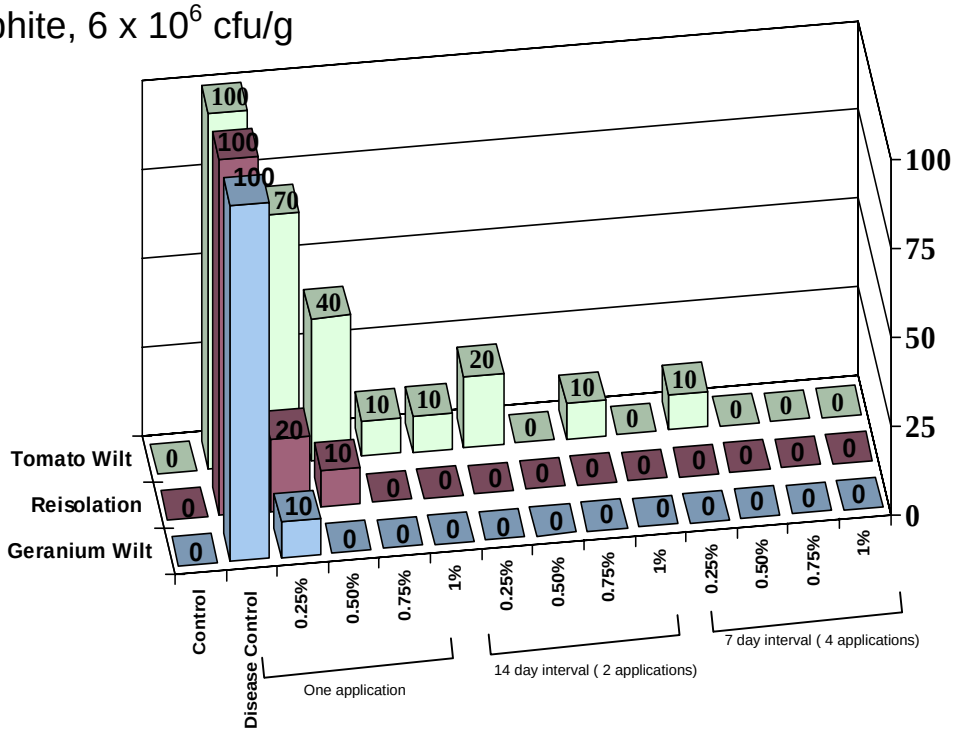
In some areas of the State, where canker has spread rampantly, entire groves in the middle of these "hot spot" areas that were on a K-Phite program did not contract canker.

As a result of these field observations and findings, K-Phite Systemic Fungicide was allowed to be used for control of citrus canker, under the provisions of the United States Environmental Protection Agency, Federal Insecticide, Fungicide, and Rodenticide Act, in consultation with the Florida Department of Agriculture, Pesticide Division.

## PREVIOUS SUCCESSFUL SIMILAR RESEARCH

K-Phite's control of *Xanthomonas* based citrus canker was not surprising. Similar *Xanthomonas* based and related bacterial disease control was achieved on other crops, by David Norman, PhD, University of Florida, Apopka Research Center. 100% bacterial disease control was achieved with K-Phite, which significantly outperformed all other approved products tested.

K-phite, 6 x $10^6$ cfu/g




**HOW *K-PHITE* WORKS**

K-Phite can be both soil or foliarly applied and is rapidly absorbed by either leaf tissue or roots. It moves systemically upward and downward throughout the entire plants vascular system, translocating to the new growth, via both the xylem and the phloem with maximum and efficient effectiveness.

K-phite's primary modes of action are first fungicidal and cureative, by acting within the fungal cell walls, inhibiting further fungal or bacterial growth, by direct toxicity to plant pathogens. The second primary mode of action is by activating the plants own, natural, self defense mechanisms called systemic acquired resistance (SAR) and induced resistance (IR). A third method is thru potassium metabolism, strengthening cell wall structure and turgidity to resist disease penetration, and fourth, by fungistatic action, whereby fungal spore growth is inhibited or neutralized.

K-Phite is a highly selective, biological, non-toxic systemic fungicide against numerous fungal pathogens, plant disease isolates of Phytophthora, Rhizoctonia, Pythium, Bacterial and Fusarium, and others plant diseases.

"K-Phite" is uniquely formulated, by a patented process, and it's use to control canker, is allowed, provided that application is made according to registered and approved label rates, and that application directions are followed. Applications should begin prior to flowering and continue thru the Fall.

**NATURAL DISEASE RESISTANCE**

All plants are able to fight off disease pressure through natural, self defense, disease suppression or elimination methods, which occur through rapid cytological action, and by triggering other plant cellular phytoalexin accumulations and metabolic changes and other disease resistance inducers.

Resistance to bacterial canker spread, in the internal cells and intercellular space, is related to their structure and strength, and tree health is ultimately determined by its cells ability to effectively produce and transport antibacterial disease fighting compounds.

Plant defense mechanisms normally activate and “kick into gear” when attacked by disease or insects. One method is to wall off the pathogen by killing off surrounding cells, somewhat like a fire line around a forest fire, as is apparent with canker symptoms on citrus. This “halo effect” is commonly observed as the yellowing around a diseased area, such as with bacterial canker. But the plant responds further, by releasing various chemical compounds that alert the rest of the plant to begin producing other defensive compounds that increase plant resistance to infection or attack at other sites on the plant.

**CANKER ATTACK MECHINISM**

Initial bacterial canker infection probably cannot be avoided because of its mode of action of attacking already wounded, damaged leaves and other plant parts. It is believed to be primarily spread by wind and rain, and by other physical means such as equipment, insects and animals.

Canker’s first goal is to saturate the intercellular spaces with water, and then to destroy epidermal plant cell structure, by secreting cell wall degrading enzymes, toxins and extracellular polysarrharides (EPS).

It is at this point of attack that ideal disease control can be achieved, with K-Phite systemic fungicide, and the disease cycle stopped, before the cells are invaded and further colonization, sporulation, reproduction, and dissemination of the bacteria to the entire tree, and adjoining trees is achieved.

Proper nutrition, with well balanced fertility programs, in disease fighting is well known, and documented. Trees on a proper, balanced nutritional program, are better able to withstand the attack by citrus canker, on at least two fronts, by physical barriers, and by chemical self defense methods as previously mentioned.

Physiologically, cells that have thicker cuticles, and higher internal turgidity, with better chemistry, have a better first line of defense through physical barriers that are more difficult for bacterial toxins to chemically infiltrate. Healthy cells, with balanced nutrition are also better able to produce more effective disease inhibiting compounds, all designed to prevent the spread of disease.

## K-PHITE AND PLANT NUTRITION

A nutritionally healthy tree is easier to protect from disease, than a malnourished one. All plants have a self defense, disease immune system that is affected positively or negatively, by its nutritional status.

K-Phite Systemic Fungicide can be applied directly, as a stand alone application, to control citrus canker. However, its ability to protect citrus from canker and other diseases is enhanced by good nutrition, just as is the case with human health; and, K-Phite is well suited for combination applications, with foliar NPK fertilizers.

> "The combination of pesticide with fluid fertilizer has been shown to enhance crop growth more than if a material was applied separately (commonly know as synergistic effect) because the presence of fertilizer makes possible quick, vigorous growth of the crop enabling the crop to more effectively compete with pests held in check by pesticide; and/or the presence of pesticide increases effective utilization of fertilizer. Applying fertilizer in combination with pesticides will enhance the effectiveness of the pesticide on its target."[1]

Damaging hurricane winds, with excessive rainfall, and insect damage such as leaf miners, have resulted in severe tree damage with greater potential for bacterial canker disease potential.

Returning a stressed or injured citrus tree to a nutritionally healthy status, as quickly as possible, is the key, in order to achieve maximum production potential and avoid further incidence of canker.

Hedging after the first full spring vegetative flush and bloom, should be avoided if possible, in order to not further damage and expose vulnerable, new growth to bacterial canker disease pathogens.

A fertility program designed not only for production, but also for disease prevention is essential. Generally, with some exceptions, an annual program should provide for more potassium than nitrogen.

## GENERAL NUTRITIONAL RECOMENDATIONS

Our recommendations, for maximum crop production, and canker avoidance are to reduce less efficient soil applied fertilizer, by adding back more efficient NPK foliar applied fertilizers along with traditional nutritionals. These NPK foliar applications should each include K-Phite systemic fungicide.

The result will be that the soil and total fertilizer applied, will fall below BMP levels, while maximizing and exceeding nutrient uptake, over conventional means, resulting in better yields, fruit size and disease resistance.

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[1] Czajkowski, A. J. & R A Rogers, 1979, Solutions, 23:Mar/Apr

Generally this calls for lowering soil applied nitrogen, increasing potassium, magnesium and sulfur, and by eliminating soil applications of phosphorus all together, substituting instead, foliar application of all phosphorus, on mature citrus soils.

Soil application of phosphorus, that is not incorporated, is extremely wasteful, inefficient, and costly. Since one of the peak utilization periods occurs during bloom, when soils are cool, and soil phosphorus is least available, much more has to be applied, than is necessary for the crop. Phosphorus laying on the surface is chemically counter productive with other essential nutrients, but most importantly, it is readily available to loss, directly to surface water thereby, through eutrophication, causing damage to the environment. However, on new, low phosphorus soils, it is essential to incorporate primary levels of soil applied phosphorus, at least six inches deep, based on soil tests and crop requirements.

Two, light applications of foliar phosphorus, with K-Phite, one at bloom, and one six weeks post bloom, totaling approximately 10 – 15 pounds of $P_2O_5$ per acre, will be more than adequate, and less costly. Additional foliar phosphorus can also be applied August – September, for fruit sizing, along with potassium and K-Phite

Foliar NPK fertilizer applications through June are usually higher in Nitrogen, for crop setting, cell division and sizing, and higher in potassium afterwards for cell enlargement, coloring and disease prevention.

Research and grower experience shows that nutrient utilization is much more efficient, as high as 95%, with foliar fertilization, as compared from 5% to 40% for soil broadcast applications. Fertigation applications are more efficient than dry fertilizer broadcast.

**EFFICIENCY FACTORS**

A one to one (1-1) nitrogen to potassium ratio is a typical spring application; however, a two to three (2-3) or even a one to two (1-2) ratio of nitrogen to potassium (N/K) is more beneficial, for the summer application, not only for better crop production, but also from a disease resistance point of view. Light, frequent applications, as opposed to heavy, less frequent applications, have always paid off, with more and larger fruit. Trees are then also better able to fend off disease and pest attack.

Many growers have cut back on the number of fertilizer applications annually, in order to cut back on costs; regretfully, at the expense of yield, fruit quality, and tree health. Less frequent fertilizer applications are wasteful, inefficient, and damaging to the environment, and result in greater potential for attack by citrus canker.

500 boxes of citrus removes:

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| Nitrogen | 62.5 lbs | Iron | .12 lbs |
| Phosphorus | 7.0 lb | Boron | .10 lbs |
| Potassium | 88.0 lbs | Zinc | .10 lbs |
| Calcium | 22.5 lbs | Manganese | .06 lbs |
| Magnesium | 9.5 lbs | Copper | .03 lbs |
| Sulfur | 5.5 lbs[2] | | |

The BMP nitrogen rate for oranges, with some exceptions, is 200 pounds annually, which also includes 200 pounds of potassium, in a one N/K ratio. Based on the above removal chart, this is only a 31% nitrogen uptake efficiency, and 44% uptake efficiency for potassium.

The majority of the applied nitrogen and potassium is wasted and unavailable to the crop mostly because of leaching. Our sandy, low exchange capacity soils are simply not able to hold, and make available to the crop, most forms of nitrogen, and potassium, for timely uptake by the crop.

**SOILS AND ENVIRONMENTAL IMPACT ON NUTRIENT UPTAKE**

Potassium loss, to the crop, is further exacerbated, in some growing areas, by unbalanced, low cation exchange capacity soils (CEC) that are high in calcium, very low in potassium, with moderate levels of magnesium, and in some cases, elevated sodium. Because they are oversaturated by calcium, and perhaps sodium, from irrigation water, only very limited amounts of potassium can be held in the exchange capacity, easily subjecting the rest to severe leaching losses. It is no coincidence that the majority of the citrus canker finds, are on these types of high calcium, low potassium soils.

Research shows that at full field (moisture holding) capacity, that it takes only .30 - **.**50 acre inches of water per acre for full soil saturation at 12 inches soil depth. Under those conditions, it only takes an additional, 2.0 acre inches of water, to leach 50% of the applied potassium, below 12 inches deep, and become lost to the environment and unavailable to the crop because of our shallow root systems. In addition excessive and driving rainfall can also leach potassium directly from the leaves.

These are precisely the conditions that came into play during the last hurricane seasons. Just when the fruit was maturing, and the highest requirement for potassium existed, we experience our highest rainfall, and wind damage, resulting in major potassium depletion and loss to the crop.

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[2] IFAS Bulletin SP 169, “Nutrition of Florida Citrus Trees”

This is further evidenced by the fact that 2005 crop has the smallest fruit size, in recent history, which is directly related to the loss of potassium, during the critical, cell enlargement, “fruit sizing” period, after June, when fruit cell division ceases, and the cell enlargement period begins.

Even under normal growing conditions, where no hyper loss of applied potassium occurs, research, at IFAS, Fort Pierce, has conclusively shown dramatic increases in fruit size, by foliar fertilizing extra potassium during the late summer and early fall; thereby, proving the importance of potassium availability during this critical period.[3]

Maximum canker vulnerability occurres after June, when potassium translocation, from the leaves to the fruit, is greatest, and the supply is the least, leaving a nutritional, damaged leaf, open to accept the disease. This is when foliar fertilizer applications, high in potassium, combined with K-Phite can do the most good.

**PREVIOUS CANKER EXPERIENCE**

This potassium deficiency concept, is further demonstrated historically during the “canker” scare in the early 1980’s, where the pathogen was incorrectly identified as *Xanthomonas campestris pv. campestris (Xcc),* and not our present Asiatic strain, *Xanthomonas axonopodis* pv. *citri* (*Xac*).

Xanthomonas citri primarily affected citrus nurseries, that were on luxury rates of nitrogen, as high as 3,000 pounds per acre, with excessive leaf tissue levels of nitrogen, and low leaf tissue levels (<1.25%) of potassium. The nursery trees, that contracted canker, exhibited long internodal growth, on long new thin branches, with soft lime green, leaves slow to mature to a dark green color, all characteristic of excess nitrogen. These trees also took longer to grow to the proper caliper and marketable size.

With hardly any exception, nurseries that were on a weekly, constant feed basis, with overhead irrigation, of between 1,200 and 1,500 pounds of nitrogen annually, with a balanced fertility program, that had a higher N/K ratio in the Spring, and a lower N/K ratio, in the fall, did not get the disease. Leaf tissue levels of potassium exceeded 2.25%, internodal length was short and compact, branches were short and thick and leaves were thicker, and darker green. These trees generally harvested in less growing time than normal.

After our experience of 40 years of citrus fertigation, coupled also with Dr. Boman’s fertigation research, showing greater production, the constant feeding of nutrients, through low volume irrigation, particularly potassium, results in greater yield, and larger, better colored fruit.

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[3] Bryan Bowman, “Effects of P&K on the size and quality of grapefruit”

## CONCLUSION

This response is not difficult to understand, when nitrogen and particularly potassium application, are “spoon fed”, in numerous smaller increments, as light frequent applications, rather than heavy infrequent applications that subject a luxuriously applied set of nutrients, to greater leaching losses.

If fertigation, of a sound, well balanced soil nutrient program, is not possible, a liquid fertilizer injection should be made at least every two to four weeks, as a superior way to apply fertilizer to Florida citrus. It’s not that liquid fertilizers are necessarily any better than equivalent dry formulations, liquefied from the same ingredients, but that liquid fertilizers better lend themselves to be agronomically superior, light frequent applications, at a lower cost per acre. This is one case, where less, can mean more, less inputs and cost, with more productivity.

Therefore, this unfortunate loss of the “hurricane crop” potassium was the perfect precursor and scenario for the devastation that bacterial citrus canker was about to inflict on our industry.