Cooperative Extension • University of California

Central Valley POSTHARVEST newsletter

Contents:

COOPERATIVE EXTENSION
University of California
Kearney Agricultural Center
9240 South Riverbend Avenue
Parlier, CA 93648 / USA
559/646-6500

December 2003
Vol. 12, No. 3

Carlos H. Crisosto, Editor

This newsletter is posted on our website at www.uckac.edu/postharv. You must subscribe to receive a mailed copy.

Visit our websites
http://www.uckac.edu
http://postharvest.ucdavis.edu
http://pomology.ucdavis.edu

ELEVATE TO ANNIHILATE GRAY MOLD OF KIWIFRUIT – AN EMERGENCY REGISTRATION FOR A PRE- OR POSTHARVEST APPLICATION ON KIWIFRUIT

J. E. Adaskaveg[1], C. Crisosto[2], and H. Förster[1]

[1]Department of Plant Pathology, University of California, Riverside
[2]Pomology Department, University of California, Davis, located at Kearney Ag Center, Parlier, CA

The fungicide Elevate® 50WDG (fenhexamid) was granted an emergency registration for one pre- or postharvest application on kiwifruit to control postharvest gray mold caused by *Botrytis cinerea* (http://www.cdpr.ca.gov/docs/sec18/sect18s.htm). With the cancellation of Ronilan® (vinclozolin) on kiwifruit in December 2002, no registered fungicide or other treatment in the limited pesticide arsenal for kiwifruit was available that is effective for the management of gray mold. Our research over the last several years, funded by the California Kiwifruit Commission, demonstrated that postharvest applications of Elevate® to kiwifruit reduced decay caused by *Botrytis cinerea* to zero levels when applied as a dip application. Thus, with the cooperation of Arvesta Corp. (the registrant of Elevate®), the California Kiwifruit Commission submitted the emergency petition to state and federal

pesticide regulation agencies in early summer and the petition was approved in October for the 2003 season.

Old Ronilan® supplies can still be used for preharvest treatments as long as the label indicates the usage on kiwifruit. New supplies of Ronilan®, however, will no longer be labeled for kiwifruit. Elevate® was identified in our studies in 1999 as an effective fungicide for the control of gray mold. In 2001 and 2002, we obtained efficacy data for postharvest high-volume (e.g., dip, drench, and T-jet applications) and low-volume (controlled droplet applications or CDA) systems, as well as for preharvest applications. Elevate® is classified as "reduced risk" by the United States EPA. It has an extremely low mammalian toxicity, thus accommodating packinghouse workers' and consumers' safety. Furthermore, fungicide usage on kiwifruit is considered low risk because the peel is rarely consumed. We submitted the fungicide to the IR-4 program for registration on the minor crop kiwifruit and in the fall of 2000 we conducted several residue studies at the Kearney Ag Center and in commercial packinghouses in the central valley. Based on these residue studies, the residue tolerance was set at 15 ppm.

For its successful colonization of healthy fruit tissues, the gray mold pathogen *B. cinerea* depends on wounds as entry points or, alternatively, on dead or senescent tissue that is colonized before healthy tissue is being invaded. On kiwifruit, most infections originate at the wound where the stem was broken or snapped off during harvest. Some infections may also originate from colonized sepals. Although preharvest fungicide treatments may reduce total spore inoculum of *B. cinerea* in the kiwi vineyard, the stem of the harvested kiwifruit is still very susceptible to gray mold because most fungicides, including Elevate®, are not systemic. Elevate® is highly effective as a protective treatment of non-wounded plant surfaces and as a wound-protection fungicide of harvested fruit. In our studies, preharvest treatments with Ronilan® or Elevate® just partially reduced postharvest gray mold decay. Only high-volume postharvest applications with Elevate® that are done immediately after harvest were completely effective in protecting the stem wound from infection. It is critical, however, that the stem wound is sufficiently covered with the fungicide. Thus, application method was the most important parameter determining the efficacy of the treatment.

The labeled postharvest application rate for Elevate® is 24 oz of the product per 200,000 lb of fruit. Application volumes may range between 8 gal and 100 gal of an aqueous solution per 200,000 lb of fruit. Low volumes of 8-25 gal are applied with controlled droplet or air-nozzle systems, whereas high volumes of 26-100 gal are applied with T-jet, flooder (drenchers), or dipping systems. Residues of 3 to 7 ppm should be targeted to obtain excellent decay control. Because kiwifruit are traditionally kept dry during postharvest handling, the wetting of the fruit is of concern to some packers because of potential fruit staining. In laboratory studies by other researchers and by us, water staining occurs only on a small percentage (< 1%) of fruit treated in water application systems. Still, water staining may be a problem when large volumes of kiwifruit are treated in this manner. Thus, we will continue to evaluate fungicide-treated fruit using high-volume application systems for staining problems during the cold-storage period (2003-2004). High-volume applications are the best way to ensure that the fungicide is effectively covering the stem wound. Before packing, excess wetness on the fruit surface can be removed by brushing or by using sponge rollers. Another strategy is to store fungicide-treated and graded fruit in bins until orders are received from retailers, thus allowing time for drying. Damp fruit that is put into storage should dry within a few days.

Treatment of kiwifruit with the new fungicide Elevate® should keep postharvest decay losses

caused by *B. cinerea* to a minimum. An important consideration before treating fruit with a postharvest application of Elevate® is to select fruit identification code stickers with the proper adhesive for wet fruit. Furthermore, because different export markets have their own regulations for acceptance of pre- and postharvest treatments of fruit, the use of Elevate® should be considered based on specific requirements of the export destinations. Many countries default to US-EPA established tolerances, however, some countries do not. Therefore, the importer or the country that the kiwifruit shipment will be exported to should be consulted. For further information contact the California Kiwifruit Commission.

PRECONDITIONING GUIDELINES FOR KIWIFRUIT SHIPPERS

Dr. Carlos H. Crisosto,
Pomology Department
University of California, Davis

This protocol will deal specifically with preconditioning at shipping point. This preconditioning treatment, including ethylene exposure, is only necessary on kiwifruit that have been in cold storage for less than 4-5 weeks. Kiwifruit ripening is triggered by a cold ethylene treatment but maintaining low temperature slows softening down. As the fruit warms up at the warehouse/retailer stores, ripening will continue.

Kiwifruit should be picked according to soluble solids content (SSC). Kiwifruit must be picked to correspond with the actual minimum maturity index of at least a 6.2% soluble solids content (SSC) when inspected at the shipping point. To assure fruit quality and consumer acceptance, we recommend picking kiwifruit when it reaches at least 12.5% RSSC measured after ripening. Sensory evaluation research clearly states that SSC equal to or higher than 12.5% at consumption time assures consumer preferences.

To precondition well mature kiwifruit, 100 ppm ethylene exposure per 12 hours is recommended. A short ethylene exposure of 6 hours is enough to precondition well mature kiwifruit that have been in storage for at least one week.

I. Preconditioning Treatment

Place cold kiwifruit in any type of container with polyliners at 32-34°F in a 40-48 ft. truck or ripening room with a temperature setting control. The types of kiwifruit containers such as tray packs, volume fill packages, or tri-wall containers with box polyliners do not interfere with the ethylene treatment. We recommend the use of polyliners to protect the kiwifruit from water loss and premature shriveling. The ripening treatment should take place far away from any packing facilities to avoid ethylene contamination during long-term storage of kiwifruit.

Ethylene applied at 100 ppm for 12 hours at 32-36°F will induce uniform kiwifruit softening and starch conversion into sugars (ripening). A 6 hour ethylene treatment is enough to precondition kiwifruit that have been in storage for more than one week. After venting, cold ethylene-treated kiwifruit can be stored back in cold storage but in a separate room away from long-term storage of kiwifruit.

Kiwifruit treated at 32°F - 34°F and maintained near 32°F may last up to 3 weeks for weak kiwifruit and up to 6 weeks for strong kiwifruit. After being transferred to higher temperatures, kiwifruit will soften according to flesh temperature (Table 1).

Table 1. Rate of kiwifruit softening after cold ethylene preconditioning treatment (32-36ºF) on cold kiwifruit.

Temperature	Pounds Lost Per Day
55ºF	1.5
68ºF	2.7
77ºF	3.0

The post treatment temperature management at the receiving site should be adjusted according to the anticipated consumption schedule using Table 1. The temperature during shipping should be set near 32-36°F.

Warm kiwifruit ethylene treated at warm temperature and then cooled down to below 36°F will reach 3 lbs. within approximately six days even when held at 32°F after the treatment. We do not recommend preconditioning warm kiwifruit. We recommend preconditioning cold kiwifruit to reduce potential decay, shriveling, undesirable fast fruit softening and to maximize postharvest life.

II. Ethylene Treatment Systems

The "Shot" and "Flow-Through" systems are the two techniques by which ethylene can be applied to kiwifruit. In either case, make sure your ripening room or truck is "well sealed". These two ethylene application systems can be done by using compressed ethylene from a cylinder.

The Shot System – A measured amount of ethylene is introduced into the room. The room can be completely full. Ethylene shots from a cylinder may be applied by flow using a gauge that registers the discharge of ethylene in cubic feet per minute. The required ethylene application is made by adjusting the regulator to give the appropriate flow rate and then timing the delivery of gas. The amount of gas needed for a room is calculated by using the following information:

C = ppm of ethylene required (100 ppm)
V = volume of room in cubic feet
F = flow rate of gas (measured from flow meter) in cubic feet per minute (CFM)
T = time (in minutes) for which gas is allowed to flow

Plug this information into the following formula:

$$T = (C \times V) / (F \times 1{,}000{,}000)$$

For a 48-foot trailer (2,825 cubic feet), a desired ethylene concentration of 100 ppm and an ethylene flow rate of 0.018 CFM (or approximately 0.5 liters per minute), the equation would be as shown below:

$$(100 \times 2{,}825) / (0.018^* \times 1{,}000{,}000) = 15.7 \text{ minutes}$$

* To convert the above equation from cubic feet per minute to milliliters per minute, multiply by 28.32.

Flow time is easily measured with a stopwatch. The room should be ventilated before each application by opening the doors for at least one-half hour. In the case of kiwifruit just harvested or stored for less than a week, kiwifruit should be treated for at least 12 hours. If kiwifruit have been in cold storage for more than a week, a 6 hour ethylene treatment will trigger ripening. In both cases, a ventilation fan should be provided.

The Flow-Through System – With the "Flow-Through" system, ethylene is introduced into the room continuously rather than intermittently by using compressed ethylene from a cylinder or ethanol from a catalytic generator. The room can be filled to capacity with fruit. The flow of ethylene is very small and it must be regulated carefully. Regulate ethylene by reducing pressure using a two-stage regulator and passing the gas into the room through a metering valve and flowmeter. To prevent buildup of CO_2 or C_2H_4, fresh air is drawn into the ripening room at the rate that ensures a change of air every six hours (360 min.). The air should be vented through an exhaust port in the rear of the room. Fan size or Ventilation Fan Delivery, (measured in cubic feet per minute), is calculated using the following formula:

Ventilation Fan Delivery = Volume of Room (cubic feet) / 360

The ethylene flow rate (in CFM) needed to maintain 100 ppm in the room is calculated as follows:

Ethylene Flow Rate (CFM) = Ventilation Fan Delivery (CFM) x 100/1,000,000

In milliliters per minute, the flow rate is:

Ethylene Flow Rate (ml/min.) = Ventilation Fan Delivery (CFM) x 2.8

Monitoring gas in a "Flow-Through" system can be done with a "sight glass" in which ethylene bubbles through a water trap on its way to the ripening room.

III. Ethylene Sources

Presently, there are two sources to commercially apply ethylene to kiwifruit: (1) ethylene generated from alcohol as ethylene source (catalytic) and (2) compressed ethylene from a cylinder.

Ethylene Generator – The ethylene generator is a machine in which a liquid (ethanol and catalyst agent) produces ethylene when heated. The generator combines a simple heater with a system for attaching a bottle of a generator liquid. Ethylene can be applied by using ethylene generators in position 1, in a "well sealed" 48 foot-trailer (2,825 cubic feet) or position 2, in a trailer not well sealed. We recommend measuring ethylene levels initially in the season for each operation.

Ethylene Cylinder – Use only explosion-proof mixtures. Check with your provider. Ethylene tanks require a regulator with a CGA-350 fitting. The duo stage regulator delivery pressure should not exceed 250 psi.

IV. Safety Precautions

Mixtures of ethylene gas and air are potentially explosive when the concentration of ethylene rises above 3.1 percent by volume, which is 30,000 times greater than the concentration required to trigger kiwifruit ripening.

1. Do not permit open flames, spark-producing devices, fire, or smoking in a room containing ethylene gas or near the generator.

2. All electrical equipment, including lights, fan motors and switches, should comply with the National Electric Codes for Class 1, Group D equipment and installation.

OPTIMUM PROCEDURES FOR RIPENING KIWIFRUIT

Carlos H. Crisosto

Most consumers prefer to purchase kiwifruit that are near ripe ("ready to eat"). To ensure good tasting, "ready to eat" fruit, kiwifruit should be ripened at any step during postharvest handling before consumer consumption. This is essential for early season, freshly harvested kiwifruit. To assure good flavor of kiwifruit when ripe, we recommend picking them when they reach at least a minimum of 6.5% SSC measured in the field or 13% SSC after the accelerated ripening test. Flesh firmness is the best indicator of kiwifruit ripening and predictor of shelf life. Fruit that measures 2-3 pounds-force flesh firmness is ripe and "ready-to-eat".

Ripening at the Shipping Point (Ethylene pre-conditioning treatment)

Ethylene applied at 100 ppm by using the "shot system" for 12 hours within a 0 to 20°C temperature range will induce ripening as indicated by uniform kiwifruit softening and starch conversion into sugars. Ethylene exposure can be shortened to 6 hours by using a catalytic generator (C_2H_4) or flow through application system. Ethylene pre-conditioning treatment (100 ppm for 12 hours) is only effective on freshly harvested kiwifruit or those that have been in cold storage for less than 5 weeks. Fruits kept in cold storage for longer

than 5 weeks will ripen upon transfer to ripening temperatures of 59°-70°C (15-21°F) by their own ethylene.

The temperature setting during treatment and shipment should be adjusted according to the anticipated consumption schedule. To prevent softening due to delayed shipments, apply ethylene to cold kiwifruit. Cold kiwifruit treated at near 0°C and maintained at that temperature may be held up to 5 weeks. These kiwifruit will reach a firmness of about 3 pounds in 2 to 3 days after being transferred to 20°C.

Application of ethylene pre-conditioning treatment: Place kiwifruit in a ripening room with good temperature and relative humidity control. The type of kiwifruit container, such as tray pack, volume fill packages, or tri-wall containers with polyliners, does not interfere with the preconditioning treatment. The ripening room should be located far away from any packing facilities to avoid ethylene contamination of long-term storage kiwifruit. High relative humidity (90-95%) is especially recommended when ripening is carried out at temperatures higher than 7.5°C (45°F). The temperature setting during treatment and shipment should be adjusted according to the anticipated consumption schedule (Table 1).

Table 1. Rate of kiwifruit softening after ethylene treatment at 20°C (68°F).

Temperature		Days to reach a firmness of 3 lbs-force
°C	°F	
0	32	6.5 to 7.0
7.5	45	6.0 to 7.0
20	68	3.0 to 4.5

If shipping is delayed after treatment, fruit will reach a firmness of about 3 pounds-force within six days when held at 0°C (32°F). In this case, the temperature setting during storage and transportation should be close to 0°C (32°F).

Cold kiwifruit treated at near 0°C (32°F) and maintained at that temperature may be held up to 5 weeks. These kiwifruit will reach a firmness of about 3 pounds-force in 2 to 3 days after being transferred to 20°C (68°F). The temperature should be set near 0°C (32°F) during transportation.

Ripening at the retail end

As a general rule, non-conditioned kiwifruit received in your warehouse that have been in storage less than 4 weeks or have a flesh firmness level of greater than 8 pounds should be ripened by using ethylene at warm temperature.

Pre-conditioned kiwifruit firmness must be tested upon arrival to the warehouse or retail store and handled according to its rate of softening and your rotation time. Fruit that have been in storage equal to or longer than 4 weeks or have a flesh firmness of less than 8 pounds can be ripened close to "ready to eat" by temperature management only.

In all the cases, temperature conditions for kiwifruit during storage and treatment should be adjusted according to your anticipated marketing/selling schedule. The flesh softening rate of kiwifruit is about 2.0 pounds per day when held at 20°C. Softening can be slowed down when fruit is stored at lower temperatures.

In general, kiwifruit should always be kept at temperatures below 7.5°C (45°F) and enclosed in liners unless they are going to be consumed within 3 days.

References

Crisosto, Carlos H. 1997. Final preconditioning guidelines for kiwifruit shippers. Central Valley Postharvest Newsletter 6(1-2):1-4.

Crisosto, Carlos H., David Garner, and Gayle M. Crisosto. 1997. Kiwifruit preconditioning protocol. Acta Horticulturae 444(2):555-559.

Ritenour, Mark A., Carlos H. Crisosto, David T. Garner, Guiwen W. Cheng, Juan Pablo Zoffoli. 1999. Temperature, length of cold storage and maturity influence the ripening rate of ethylene-preconditioned kiwifruit. Postharvest Biology and Technology 15:107-115.

Crisosto, C.H., David Garner, and Billie Shaver. 1992. Studies on kiwifruit ripening, Progress Summary Report, 1992. Report to Kiwifruit Commission, 1 p.

Crisosto, Carlos, H. 1994. Ripening guidelines for kiwifruit handlers. Report to California Kiwifruit Commission, 4 pp.

Crisosto, C.H., M.A. Ritenour, D.T. Garner, and G.M. Crisosto. 1996. Affects of maturity and postharvest factors on the ethylene requirement for kiwifruit ripening. 1995-96 Kiwifruit Report. California Kiwifruit Commission, Sacramento, CA, 20 pp.

Crisosto, Carlos H., Gayle M. Crisosto, and David Garner. 1997. Kiwifruit storage compatibility. Preliminary Report to the California Kiwifruit Commission, 1997, 5 pp.

Central Valley Postharvest Newsletter – Published two times per year

Subscription Order Form

Mail to: Lois Strole • UC Kearney Ag Center
9240 S. Riverbend Ave. • Parlier, CA 93648 • USA
Phone: (559) 646-6545 • Fax: (559) 646-6593

Subscription rates:

United States ☐ 1 year = $25 ☐ 2 years = $48 ☐ 3 years = $72 ☐ 4 years = $95

Outside U.S. ☐ 1 year = $40 ☐ 2 years = $76 ☐ 3 years = $114 ☐ 4 years = $150

☐ Enclosed is a U.S. Bank Check made payable to **UC Regents**

Please bill my: ☐ VISA ☐ Mastercard – Account # _____

Expires on: _____ Signature _____

Send subscription to: (***Please type or print neatly***)

Name: _____

Company: _____

Address: _____

City, State, Zip: _____

Country: _____ Email: _____

Phone: _____ Fax: