Easter Lily Research Foundation

OF THE PACIFIC BULB GROWERS ASSOCIATION Vol. 30 NO. 2 FEB 17 2005

"Quality Lilies through Cooperative Research"

PYTHIUM YEARLING FUNGICIDE TRIALS 2004

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INTRODUCTION

Field grown Easter Lilies are planted in the fall of each season and must endure a prolonged rainy season from October through April of water-saturated soils with little foliage growth to promote root growth. Lily bulb field soils are generally high in clay and organic matter, which promotes the constantly moist conditions for both high bulb yield and also for root infection by Pythium root rot. Locally called "Upper/Downer Disease", the disease causes progressive dwarfing in areas along the planted row. The disease presents as waves where the plants get smaller then larger then smaller as you sight down the row. Adjacent rows will have an entirely different pattern of dwarfing, causing the field as a whole to appear very un-uniform even from a distance.

Easter lily bulbs are dependent on the establishment of a vigorous basal root system being developed in the fall and winter before they make rapid foliar growth in the spring. Plants that have been attacked by Pythium in the fall through winter "rooting" season are dwarfed for the entire following growing season and are known locally as "downers". Past trials have shown that treatments must be applied in furrow at planting to be effective at preventing "downers". Even applications of otherwise efficacious materials made as early as March have failed to reverse the winter root growth loss and have resulted in stunted "downer" plants.

Past trials have tested the following treatments (both alone and in various combinations): Subdue (Fall and Spring), Cloroneb, Metam drenches, Manual root clipping, Aliette (Fall and Spring), Banrot, Banol, Busan, Captan, Topsin-M, Heritage (dips and in-furrow), Terrazole, several numbered compounds, and the bio control organisms: Rootshield (Tricoderma), Soilgard (Gliocladium virens), Deny (Burkholdia cepacia), and several strains of Mycorrhizal inoculations.

In the last few years a new fungal pathogen (identified as a Fusarium of unknown species) has begun causing bulb losses. The symptoms of this disease are of a rusty orange brown "rusty crud" discoloration of areas of the bulb scales, multinosing of bulbs, odd sideways and upside-down growth of the growing points, and areas of the bulb that appear to have been chewed away, with rough callusing of the surrounding tissue. This disease appears to be enhanced by high nitrogen fertility (especially organic nitrogen), warm soil temperatures, and biocide type fumigants (MB, Metam). Field losses of up to 50% have been observed, often with little forewarning, seemingly overnight after a period of warm soil temperatures. The 2002, 2003, and 2004 trials were tailored to look at furrow fungicide applications that would control Pythium and Fusarium.

MATERIALS & METHODS Easter Lilies {variety Nellie White}

6 to 7 inch circumference sized “yearling” bulbs were used in this trial. The bulbs were harvested August 22nd -26th 2003 from ELRF Nematode Control Trial plots, graded to uniform size August 26th to 29th. They were dipped in a standard fungicide solution (Terraclor 2.14 + Thiram 2.14 + Captan 1.07 + Terrazole 0.1 + Systec 1998 1.2 + Vitavax 0.91 # Active Ingredient per 100 gallons of water) on Aug 28-29 prior to planting on September 2cd, in a “soft” loosened very dry furrow (sunny & warm at planting).

Bulbs were hand set at 5 bulbs per foot of row in a staggered pattern with bulbs 6” apart across the row and 4” between them along the row. There were 1 to 2 replicates of each treatment. Each replicate contained 100 bulbs and consisted of 20’ of row.

Test Treatments were made over planted bulbs in furrow just prior to covering and final hilling. Liquid treatments {Heritage, Terrazole, Banol} were applied in a 12” band using a TG-8002 Even band nozzle at 30 PSI in 20 gallon of carrier water per acre. Granular treatments {Subdue 1G} were made in a 12” band with a shaker bottle. Dip treatments were made in a small 20 gallon tank with freshly spiked dip solution taken from the main dip tank which was then spiked with the test chemical. All dips were one hour at 55 degrees F.

Bulbs were fertilized with 1000# per acre of Simplot 6-20-20 XB placed 3” under and 3” to the side of the bulbs, and top-dressed with 260# Calcium Nitrate on March 16 and April 29th 2003. **Nematode control** was provided by a combination of pre-plant fumigation {Telone 40 gallons injected 18” deep + Metam 75 gallons per acre rototilled into the upper 6” of soil}, and in-furrow application of Fenimophos 4# A.I./A plus Ethoprop 4# A.I. as bulbs were being hilled up. **Weed control** was provided by application of Roundup {2 qts} and Direx {2 qts} on 10-21-03, Direx 0.8 #AI + Devrinol 1.6# AI on 12-17-03, Direx 0.75 # AI on March 31 04, and Lontrel {12 Oz./A} on 7-21-04, plus selective hand weeding.

Foliar **Botrytis** disease was controlled during the entire growing season by routine applications of Kocide {copper hydroxide}, Nordox, CCN + Mancozeb, Daconil, and Chipco GT fungicides.

All plots were overhead watered during the growing season by Rainbird #20 sprinklers on an as needed basis.

TREATMENTS

BULB DIP	FURROW	FOLIAR SPRAY
STANDARD DIP	NONE	NONE
STANDARD DIP	NONE	FOSPHITE 3 X
STANDARD + HERITAGE 12 Oz	NONE	NONE
STANDARD + HERITAGE 12 Oz	NONE	FOSPHITE 3 X
STANDARD + BANOL 20 Oz	NONE	NONE
STANDARD + BANOL 20 Oz	NONE	FOSPHITE 3 X
STANDARD DIP	SUBDUE 1G 81#	NONE
STANDARD DIP	SUBDUE 1G 81#	FOSPHITE 3 X
STANDARD DIP	HERITAGE 1 #	NONE
STANDARD DIP	HERITAGE 1 #	FOSPHITE 3 X
STANDARD DIP	BANOL 2 QT	NONE
STANDARD DIP	BANOL 2 QT	FOSPHITE 3 X
STANDARD + ALIETTE 3 #	SUBDUE 1G 81#	NONE
STANDARD + ALIETTE 3 #	SUBDUE 1G 81#	FOSPHITE 3 X
STANDARD DIP	TERRAZOLE 7.5 #	NONE
STANDARD DIP	TERRAZOLE 7.5 #	FOSPHITE 3 X
STANDARD + FENAMIDONE 14 Oz	NONE	NONE
STANDARD + FENAMIDONE 14 Oz	NONE	FOSPHITE 3 X

FOSPHITE GROWING SEASON APPLICATIONS

Applications were made to Rep. 3, which was placed in the lowest, wettest, most disease prone area of the trial rows.
Dose was 2 Quarts FOSPHITE per acre in 60 gallons carrier water per acre. TG 8002 E nozzles at 30 PSI backpack

January 22 2004 1:30 PM Single top band over plants application. Plants are now 100% emerged from 5 leaves to 3 ½" rosettes. Sunny Warm dry plants and soil surface, no wind, sprayed over Nordox + Chipco GT applied 1-21-04

March 31 2004 4:45 PM 1 Nozzle over top of plants and one on each side. Plants in full rosette, dry soil and plants, slight NW wind, Over Kocide+Chipco applied in the AM. Slight Roundup residue (in tank) injury to SE 7' of check plot #3.

May 13 2004 1 PM Plants showing buds, spray sides of plants with only a little over the top, fog just clearing at application.

EARLY SEASON OBSERVATIONS

Observations began as the crop emerged from the ground and continued on a weekly basis throughout the spring. No obvious differences could be observed in any of the experimental plots in the early "rosette" stage of crop growth. The first apparent crop symptoms were observed in mid June 2004 as the plants made their growth spurt prior toward flowering.
A Visual rating of each plot for overall crop <u>vigor</u> of the plot was recorded on June 10th 2004.
A visual rating score of "10" = excellent and "1" = poor was used. The number of flower buds per plot were recorded. The percentage of "downer plants" was recorded.

HARVEST METHODS

On September 13th the author recorded the number of "green" "yellow" or "brown" plants in each plot. The shortest and tallest plants in each plot were recorded.
At harvest (September 24 & 27) all stems in each plot were hand pulled and all adhering bulblets were picked. Bulblets and stems were then weighed, and divided by the number of plants per plot to determine average yield per plant. Bulblets recovered while bulbs were being picked up were added to the total weight for each plot.
Bulbs were harvested using a modified one-row potato digger and all bulbs were visually inspected for root heath by the author. Root rating was based on the color (white or with lesions), quantity, and vigor of the bulbs root system.
There were no visual Fusarium symptoms in any bulb in this trial. All bulbs were 100% white.
After visual grading, each individual bulb of every plot was graded by hand using specially made circumference calipers that measure the bulb circumference in one-quarter inch increments for recording on the master tally sheet. This data is used to calculate the average bulb size, bulb size plot population standard deviation, bulb survival, summer sprouted bulb percentage, and bulb division into commercial size grade categories.

The 2004 growing season was not conducive to the development of **Fusarium** disease, but was conductive to **Pythium** disease. The season started out with warmer than normal soil in the fall and winter, and this continued on through the spring and summer. Root systems have been above average in 2003 and 2004 which both had warmer fall ~ winter soil temperatures.

TRIAL RESULTS

HERITAGE has been tested two years, 2003 and 2004 as an in furrow treatment and one year, 2004, as a bulb dip. It was tested years ago on Ace bulblets as a bulb dip at 1# x 50%.

In the 2004 trial

The Heritage **Dip** provided the greenest foliage at harvest but the worst bulb yield, and only average foliage weight. Adding the Fosphite sprays to the Heritage dip resulted in remarkably improved bulb yield, but gave slightly less green foliage of slightly lighter weight.

As a **Furrow spray** Heritage gave average bulb size, and the second greenest harvest foliage and second heaviest foliage weight. Fosphite sprays further increased bulb size, but decreased foliage weight and quality.

Basal roots in all Heritage treated plants were rated good to excellent.

In the 2003 trial the Heritage **furrow** spray gave the second highest yield, and the least variability between clipped and unclipped reps. It also gave the longest whitest basal roots and 100% white bulbs.

SUBDUE provided the highest bulb yields in the 2000, 2001, 2002, and 2003 trials. The four-year average bulb size increase was 0.141". In all trials Subdue has shown either no Pythium downer symptoms, or a very low percent. Past trials have not shown Subdue treated plants to have the highest root ratings. Commercial use of Subdue has shown some Pythium resistance in some plantings.

In the 2004 trial Subdue had the lowest percentage of Pythium downers in the trial. Root systems were rated as Good to Excellent. Crop yield was average, however the addition of the Fosphite sprays raised yields to the third highest in the trial. Foliage Quality and weight was pretty low in this trial but once again the addition of Fosphite sprays improved foliage condition and weight.

In the 2002 trial the addition of a 4.5 # AI/A Topsin summer drench to the Subdue treatment resulted in major improvements in the basal root system. The addition of summer Topsin improved foliage condition at harvest, however the bulb yield was not increased with the Topsin drench.

ALIETTE DIP + SUBDUE FURROW

Limited trials in the past showed marginal to no efficacy from dip, drench, furrow, or foliar applications of Aliette on field grown or greenhouse lilies. This trial (the 1st) used an Aliette **dip** plus Subdue in furrow application to try to break Pythium resistance to Subdue.

In the 2004 trial this combination showed slightly more downers than straight Subdue plots. Crop yield however was improved over straight Subdue. Foliage weight and quality was vastly improved over straight Subdue. The combination gave the highest foliage weight in the trial.

Once again the addition of Fosphite spray enhanced crop size, but had the worst foliage quality (most brown dead stems) in the trial, and average foliage weight.

BANOL (Dip or In Furrow)

Banol is a carbamate systemic soil and foliar fungicide with a 6 to 8 week soil residual. Residual is increased in acid soils. Like Subdue, it is strongest against “water molds” like Pythium and Phytophtora. Unlike Subdue, there has been no reported resistance to Banol by Pythium. Banol contains 6 pounds active per gallon. Banol can be used as a soil drench, and has a 12 hour re-entry. The use label lists both field and greenhouse grown Easter Lilies and a use rate of “3 Oz. Per 10 gallons water applied at 3 quarts solution per 10 square feet”. (That’s as high as 7.7 gallons product per acre if you treated 43,560 sq. ft.) Banol is taken up by the roots and translocated upwards to the leaves.

Banol was tested in **3 trials in 1999-2000** at rates of 1 pint, 1 quart and 2 quarts.
In **2000-2001** Banol was tested in 2 trials at rates of 1, 1.5, and 2 quarts / Acre.
In the 1999-2000 trial, even at the low {16-ounce} use rate Banol provided similar efficacy to that of Subdue. Other tests showed no phytotoxicity on small “scale sized” planting stock at use rates of 1 to 2 quarts per acre.

In the **2003 trial**, efficacy improved as the rate increased from 1 to 2 quarts. Crop yield was very good at both use rates, but foliar vigor was best at the high use rate.

A trial in the 1980’s showed that adding Banol to bulb soaking solutions at a rate of 1 Quart per hundred gallons water was somewhat phytotoxic to lily bulblets.

IN THE 2004 TRIAL Banol was tested as a bulb dip additive or an in furrow spray.

As a Dip Banol was added to the standard dip at 20 ounces per hundred gallons. This treatment resulted in the poorest harvest foliage condition (least green) and poorest foliage weight in the trial. Crop yield was also among the lowest in the trial. Replicate #2 in the wetter area of the field experienced 93% “downers” and had poor roots at digging. The addition of Fosphite foliar sprays improved crop yield by quite a bit, reduced “downers”, and very slightly improved foliage weight.

As a Furrow Spray Banol was tested at 2 Qts. Per acre. This gave crop yield improvements similar to Subdue, but did not control “downer” symptoms as well as Subdue. Harvest foliar condition was not much different than the check treatment.
The addition of Fosphite foliar sprays improved the yield, and foliage weight, but not the foliage condition or the percentage of “downers”.

Banol in furrow has a track record of out-yielding untreated checks in three out of four years, but not in the 2002 trial.
Cost per acre for a 16 ounce dose is +/- $41, and for a two quart dose $163 so Banol would be competitive with Subdue in this market. Banol provides an alternate mode of action for Pythium control with no reported resistance. At this time Banol is in the process of registration in the state of California.

TERRAZOLE in furrow

Terrazole has been tested twice (2003 and 2004) as an in furrow treatment of 7.5# of 35% WP per acre.
In the 2003 Trial Terrazole gave no noticeable Pythium control and a reduction of crop yield when compared with untreated checks. When applied to root clipped planting stock Terrazole appeared to cause phytotoxicity.

In the 2004 Trial Terrazole appeared to give some Pythium control and did improve crop yield. Under more severe disease pressure (Reps A and C) the addition of Fosphite foliar sprays improved yield and foliar condition.

FENAMIDONE dip

Fenamidone was **tested in 2000** (as EXP 10623 A**) as a furrow treatment** at
14 Oz.
14 Oz + Aliette 3 #
28 Oz. and
42 Oz (of 44% Flowable per acre)

Results were not reported at that time due to secrecy agreements. There was a slight decrease of "downer" symptoms at the higher two use rates. Basal root scores were the best in the trial at the highest three use rates. Crop yield was not improved.

In the 2004 Trial Fenamidone was tested as a bulb dip addition at 14 Oz per hundred gallons. Control of "downer" symptoms was very good (second lowest in the trial) and foliage weight was up. Bulb Yield was very high (second best in the trial, almost a tie for first place).
When Fosphite foliar sprays were added to this treatment bulb size was the highest in this trial, foliage weight went up, as did foliage quality. "Downer" symptoms were not seen with this combination treatment. Note that this combination was placed in the very worst position in the field (the bottom) where disease pressure is the highest.

Fenamidone is being tested in the 2004-2005 trials as a 17 Oz. Per hundred-gallon bulb dip addition on both Scales and Yearling plantings.

FOSPHITE

This was the first trial of Fosphite foliar sprays. Fosphite is a systemic fungicide for the control of downy mildew, Phytopthora, Sudden Oak Death, and Pythium that is registered in Oregon and California (different labels) for ornamentals and lists Easter Lilies. It has a 4-hour REI, and may be applied as a drench, spray, soak, chemigated, trunk injected, or soil incorporated. It is labeled for food and ornamentals in Greenhouses and Outdoor Nurseries. Fosphite contains 6.22 # / gallon of Mono and di-Potassium salts.

There is a label warning to NOT APPLY COPPER within a 7, 10, and 20 day period (interval varies in various parts of the label) of a Fosphite application. This is because of its acidity, which is much like that of Aliette that can cause coppers to become more soluble and enter the leaf rather than staying on the surface.

In this trial coppers were applied as follows

Jan 21 04 Nordox 2# (3 PM)
Jan 22 04 Fosphite 2 Qt (1 day post copper 1:30 PM)
Feb 10 04 Nordox 2 Kocide 3
Feb 23 04 Kocide 5
Mar 2 04 Nordox 3
Mar 12 04 Kocide 5
Mar 23 04 Nordox 2 Copper Count N 2 Qt
Mar 31 04 Kocide 5 (11 AM)
Mar 31 04 Fosphite 2 Qt (same day, 4:45 PM, just 5 hours after copper)
Apr 9 04 Nordox 2.5
Apr 22 04 Kocide 5
May 4 04 Nordox 3
May 13 04 Kocide 5 (11 AM)
May 13 04 Fosphite 2 Qt (same day, 1 PM just 2 hours after copper)
May 18 04 Nordox 2 (5 days post Fosphite)
June 11 04 Kocide 5

Note that all three Fosphite applications were made very soon after a copper application without any apparent phytotoxic reaction.
The label also warns not to tank mix with liquid fertilizers, coppers, or to use surfactants. I used Kinetik Silicone surfactant on the March 31 application without a problem.

In this first trial Fosphite Improved crop yield in ALL test fungicide blocks to which it was applied. In addition the Fosphite treated area was in the lower wetter most disease susceptible area of the field. In most fungicide blocks (Aliette + Subdue, Banol furrow, and Heritage furrow were the exceptions) Fosphite gave a remarkable reduction of “downer” symptoms. In most cases however Fosphite treated plants did not have as green a foliage at harvest as non treated plants, this could be delayed copper toxicity?

Fosphite costs about $16 for a 2 Qt per acre dose.

Fosphite Trials planted in the 2004 – 2005 field include

YEARLING TRIAL
Fosphite sprayed in furrow at planting + 3 growing season applications to foliage over the entire Replicate “C” of 6 different Pythium control treatments.

SCALE BED TRIAL
Fosphite sprayed in furrow at planting + 3 growing season applications to foliage.

CULTURAL CONTROLS

Planting conditions Loose dry well drained planting furrows with soft soil beneath the bulb at planting seem to lessen the severity and spread of the disease. Downer spots will run less row feet and plants will be less affected. Tight, hard, wet planting furrows impede water drainage and allow the disease to spread further down the furrow from an initial infection.

Bulb Dip Terrazole in the bulb dip has helped control this disease in the past. The switch from Benlate (no Terrazole) to Banrot (has Terrazole) in the 1980's helped control Pythium before we even recognized we had Pythium. Terrazole has not been very successful as a furrow treatment but is efficacious as a bulb dip. Uniroyal Terrazole Is available for use in Oregon as a 35% WP that costs less and mixes in water better than the Etridiazole (Terrazole) that is in Banrot (15%).

Soil Fumigant has been implicated in Pythium disease. Symptoms of "Upper~Downer" disease were not seen until "Biocide" type fumigants were first widely used. Biocide fumigants are Metam, Methyl Bromide, Basamid, and Chloropictrin.
Chloropictrin has been implicated more often in research plots as causing the disease than the other biocide type fumigants. Telone has not caused the syndrome, however once a field has been treated with a biocide fumigant it will retain the syndrome even after a four-year sod rotation.

Wet Winters usually make the problem worse. You may not be able to control rainfall but you might be able to control how the water percolates, drains from the field, and divert additional water from draining on to the field. You do have control over land leveling and deep ripping activities to manage surface flow and percolation. Management of soil compaction should be considered for Pythium control.

Root Clipping has some effect over the disease. We have seen both positive and negative results from root clipping. In general, results were always positive through several decades of research aimed at nematode control (less downers and less harvest foliage yellowing). However in two recent Pythium trials (2002 & 2003) clipped bulbs had severe negative symptoms. These symptoms were, very late emergence, multiple weak stems / multiple noseing, corky rust colored bulb rot, poor basal plates and poor basal rooting. These symptoms appear to be unrelated to Pythium and might possibly be related to Fusarium infection, or mechanical injury at planting, or chemical injury from increased fungicide use, or possibly dehydration damage, or something else?
The injury symptoms coincided with the research station changing bulb dip practices

FROM > (Terraclor + Thiram + Vitavax + Banrot {Terrazole + Topsin-M})
TO > (Terraclor + Thiram + Vitavax + Terrazole + Topsin–M + Captan)

Dipping and Washing Tanks although this may be a sore subject, dipping and washing tanks probably help spread this "water mold" type disease. It has been obvious that dip tanks will spread foliar nematodes, and is quite likely that dip and wash tanks would also spread Pythium. Dry Dust and Slurry Spray bulb fungicide application have been researched in the past but have not been commercially adopted. It is unknown if Chlorination of wash water would alleviate the spread of Pythium in wash water, however bulbs have been treated with Chlorine in past studies (ELRF & UCD). Those studies showed positive effects (increased survival, less yellowing) and no phytotoxicity. It is also unknown to what level Terrazole in the dip tank retards Pythium transmission.

SUMMARY of SEARCH for PYTHIUM CONTROL in WATER

http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PepDisease_Con.htm
(bacterial rot control on pepper seeds)
Seed can be treated with hot water (122°F for 25 minutes) or **with Clorox® (EPA Reg. No. 5813-1; label available from Clorox at 800-446-4686)**. Mix 1 quart of Clorox® bleach (calcium hypochlorite) with 4 quarts of water to treat up to 1 pound of seed in a cheesecloth bag, add ½ tsp. of surfactant (dishwashing detergent), and submerge in the solution with agitation for 40 minutes, rinse under running tap water for 5 min, and dry seed thoroughly. Treated seed should be dusted with Thiram 75W [dithiocarbamate] (1 tsp. per pound of seed), and planted soon after treatment

http://www.ces.ncsu.edu/depts/pp/notes/Vegetable/vg1/vg1.htm
For cucumbers post harvest "If they must be washed, add 50 ppm of chlorine in the wash water."

http://www.btcproducts.co.za/clo_tecsa_clor_frutas_applicate.asp
Treatment of fertigated water (fertiliser, nutrient and biological control agent (BCA) mixes) to prevent the spread of root diseases such as **pythium**, fusarium, phytophthora, alternaria and rhizoctonia micro-organisms. This is particularly necessary where nutrient gravel film systems are used where the fertigated water is continually re-cycled or where regulations require the fertigated water to be re-cycled. Dosage : 40 ml to 100 ml of TECSA CLOR per 1000 litres of water. (2 litres to 5 litres per 50 000 litres of water).
Studies undertaken by the Horticultural Research and Development Corporation (HRDC) in Australia have shown that the most effective techniques for the **disinfestation of waterborne fungi like pythium are : ultra violet light, ozone, chlorine dioxide (TECSA CLOR)** TECSA CLOR can be used in conjunction with any other fungicide / bactericide. Our Principle's have experience where the TECSA CLOR is mixed with herbicides, insecticides etc with NO phytotoxic OR incompatible reactions. We still, however, recommend that any cocktails are tried out on small areas to prove to the user that no problems may arise. **Monitoring :: Chlorine Dioxide**
Outside of the properties, applications and approvals for our liquid Chlorine Dioxide products, the other major advantage of this technology is the ability to measure and control the dosing.
We have a number of ways of measuring the residual of our Chlorine Dioxide products. There are: For Harvest Wash, Oxine, Potato Wash And PurogenE.

Oxystix - semi quantitative measurement of residual using a dipstick. It can measure 0.5, 2, 5,10, 25, 50 and 50 ppm residuals. A color chart is on every box of OXYSTIX.
Test Kit - Quantitative process procedure which can measure the residual. This procedure can measure 0-10 ppm at 1 ppm intervals and 0 - 50 ppm at 5 ppm intervals.
For Tecsa Clor. A specific test kit that can measure 0-100ppm at 1 ppm intervals.

http://www.fao.org/Wairdocs/X5403E/x5403e07.htm
Washing produce with chlorinated water can prevent decay caused by bacteria, mold and yeasts on the surface of produce. Calcium hypochlorite (powder) and sodium hypochlorite (liquid) are inexpensive and widely available. The effectiveness of the treatment will be decreased if organic matter is allowed to build up in the wash water. The effectiveness of chlorine increases as pH is reduced from pH 11 to pH 8, but at lower pH chlorine becomes unstable. Fruits and vegetables can be washed with hypochlorite solution (25 ppm available chlorine for two minutes) then rinsed to control bacterial decay. Alternatively, these commodities can be dipped in hypochlorite solution (50 to 70 ppm available chlorine) then rinsed with tap water for control of bacteria, yeasts and molds.

http://ucce.ucdavis.edu/files/filelibrary/5453/4369.pdf (fairly detailed Chlorine Ag Article)

Calcium hypochlorite the most common source of chlorine used for disinfection of produce and produce process water. Registered formulations are 65 percent or 68 percent active ingredient (a.i.). It is available as a granulated powder, compressed tablets, or large slow-release tablets. In dry storage, calcium hypochlorite is more stable than liquid sodium hypochlorite. Phytotoxicity (bleaching or burning) of produce can occur if calcium hypochlorite granules fail to dissolve in cool wash tank water or in a hydrocooler system. A “nurse-tank” of warm water is used to fully dissolve granules before adding them to cooling or wash water. Calcium hypochlorite, beyond disinfection benefits, is reported to improve the shelf-life and disease resistance of fruits and vegetables by adding calcium to the cell wall Chlorine is highly reactive with leaves, soil, and any plant or vegetable matter whenever oxygen is present. Each chemical reaction reduces the amount of active chlorine in the water. The chlorine demand of agricultural water sources is often far higher and more prone to rapid fluctuations than sources for drinking water. Changing chlorinated water frequently or filtering out organic matter and debris is essential for effective sanitation. Pre-washing harvest bins, palletized totes, pallet skids, and, if possible, very dirty produce can prolong the useful life of chlorinated cooling water. Removing field soil before sending bins or palletized loads of harvested crop into flotation tanks, chemical treatment showers, or hydrocoolers will greatly aide in pathogen inactivation, chlorine use efficiency, and minimize the production of chlorinated disinfection by-products. The issue of disinfection by-products may be of particular concern for vegetables grown in organic or muck soils with a high humic fraction.

http://vegdis.cas.psu.edu/03Diseases/D429_Toma.html **Postharvest Rots.** To prevent rots in green wrapped tomatoes. Use chlorinated water (minimum 25 ppm) in the flume.

http://www.midkentfisheries.co.uk/algae%20control.htm
Aquasonic We have several sized **ultrasonic devices**, the largest of which is the Aquasonic unit **used in horticulture**, aquaculture, potable and wastewater applications and larger areas of water such as ornamental and recreational lakes. The transducer is capable of emitting ultrasonic vibrations up to a range of 100 metres, covering a radius of 180 degrees. It uses only 45W of power for continuous operation. Besides killing algae, it also deals with all kinds of fungi
Pythium is 100% killed by the ultrasonic waves. Smaller devices like the Aquatank and Poolsonic are designed for use in medium sized water surfaces and in swimming pools, fishponds and cooling tower basins.

http://www.growertalks.com/archive/articles/1047.asp
There are several methods for sanitizing water that add substances to the water. These methods work well, but only if carried out precisely. Shortcutting the processes generally make them ineffective. Most work better when combined with prefiltering and acidification of the water.
The most popular method—and the most often incorrectly designed—is chlorination. Chlorination is a holding tank system. This is the key design element that most growers fail to do properly. The proper dose must be put into the water and held there for 30 minutes of oxidation time. Many try to bypass the holding time with higher doses of chlorine. This invites phytotoxicity. Chlorine creates temporary molecules that damage plants. There are disagreements as to what level of free chlorine in the water is safe for irrigating plants. This point has been complicated by recent research, which proved that 2 ppm of free chlorine at the hose end is needed to kill pythium spores in water. Many horticulturists have stated in other research that 2 ppm of free chlorine is right on the edge of phytotoxicity.

The other widespread problem with chlorination is the design of the holding tanks. You want mixing and holding of the water for 30 minutes. You can't add water to the top of a tank while pulling it out the bottom. If you try this, the water will flow laterally down the side of the tank and out. You need to add water to the bottom of the tank and pull it out the top. This requires a pump with a backflow check valve. Fancy stirring devices and baffles in the tanks aren't needed, but are helpful.

The dose of chlorine that must be added to the water is calculated by working backwards. The dirtier the water, the higher the chlorine demand will be. Also, high pH water takes more chlorine. Therefore, prefiltering and buffering the water initially helps a lot. Chlorine demand will usually change throughout the year. Automatic dosage devices help here.

There's a new method of using electrolyzed water that breaks down sodium chloride into sodium hydroxide and hypochlorite that's being researched. It might be a cheap way to utilize chlorine. But you need very clear water to make this work.

A potential problem with using chlorine is the formation of trichloromethanes, chloroamines, chlorophenols and chloroacetic acids in the water when residual free chlorine reacts with organic matter as it enters recycling ponds. These compounds are related to plant herbicides. If your original chlorinated water is recycled, there's a chance that the returning water may contain these molecules. Plants, especially geraniums, may not grow well.

Chlorine dioxide (ClO2) is starting to be used now. Its use is popular in Europe, but not so common here. ClO2 is widely used to wash fish, vegetables and fruit after harvest to prolong shelf life. Many municipalities and water parks now use ClO2 to sanitize water.

The use of ClO2 for greenhouse water sanitation will become more popular in the future. Cost is a consideration at this time. Prefiltering water greatly decreases the dose needed. Even if you can't pre-filter your water before treatment**, ClO2 will operate more efficiently in dirtier water because the compound is a much stronger oxidant than chlorine**.

ClO2 doesn't react with water (hydrolyze), as chlorine does. Killing time is very short, so you only need minimal holding times after treatment. Also, if there's no light present, the chlorine dioxide is more stable. Finally, it breaks down only to harmless sodium chloride in small amounts.

Ozone is widely added to water to sanitize it. This is also a holding tank method. However, the time required to hold water with ozone is shorter than with chlorine. Again, the method is popular in Europe. Many municipalities in this country now use ozone to sanitize the water. It's the strongest oxidizer we can use for water sanitation

There's some research on adding **soaps or wetting agents** to water to destroy zoospores of pythium and phytophthora.

http://www.canola-council.org/production/foundation.html **Thiram** is a dithiocarbamate fungicide with multi-site activity against nearly all fungi, including *Pythium* species.

http://ces.ca.uky.edu/jessamine/newsletter.March%2003.doc Tobacco Pythium

Etridiazole (TERRAZOLE Terramaster) is a very important tool for controlling Pythium root rot and damping off in float systems. The float system provides a near ideal environment for Pythium to develop once introduced into the system, and now labeled controls are available.

There are phyto issues involved and it is essential that etridiazole-containing products be uniformly distributed in the float water to achieve control and to minimize phytotoxicity. In our experiments, etridizaole has provided a very high level of control of Pythium root rot, and it reduces algae levels, but it has not provided adequate control of Phytophthora in our systems. Terramaster 35 WP is labeled at 2 oz/100 gallons of float bed water, but 1 oz/100 gallons gives acceptable control with less phyto potential when disease pressure is low. These applications should be made directly to the float water. Be sure to follow label directions as to making the premix-slurry and thoroughly distribute it in the water. Terramaster 4EC is labeled preventively at 0.7 fl.oz./ 100 gallons of float water, starting no sooner than 3 weeks after seeding, with sequential applications at 0.7 fl. oz. at three week intervals for a maximum of three applications per crop. Terramaster is also labeled as a rescue treatment at 1.4 oz./100 gallons of float water. A second rescue application of 1 – 1.4 oz/100 gallon of float water can be made (see label), and is highly effective, but I urge it be used as a preventive treatment rather than letting the fungus damage the root system and then trying to stop it. Wounded roots are prime targets for opportunistic pathogens in the field black shank, soreshin, and Fusarium root rot. We have observed phyto in the form of reduced roots, white veins, and slower development in every study conducted, including at rates below the effective rates. However, the phyto we have observed in our studies is considered acceptable when compared to the serious damage Pythium is capable of producing. No application can be made later than 8 weeks after seeding.

BORDEAUX MIXTURE (1 lb bluestone copper sulfate + 2 lbs fresh hydrated lime mixture per 25 gallons of water) is labeled for ground beds as a drench to the soil when the plants have emerged and again 10 days later. This treatment will control algae and aid in the control of diseases caused by bacteria (wild fire, angular leaf spot, and blackleg), and assist in Pythium and blue mold control. Follow the label EXACTLY as to mixing instructions, because Bordeaux mixture can be toxic to tobacco seedlings. Constant agitation is required during application to avoid injury and to achieve control. Do not apply this mixture to large seedlings. The main target is actually the soil rather than the tobacco plant.

NOTE Bordeaux was tested as a bulb dip by John Lense (sp) and found to work well to control stem lesion but was phytotoxic on yield.

http://www.citrofresh.com/download/pdf/15%20-%20Citrofresh%20-%20Organic%20Sanitiser%20Range.pdf Citrofresh (citrus oils) controls pythium

http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=403887&showpars=true&fy=2004

The reduced-risk pesticide milestone has been fully met through a subcontract with **Washington State University** for several bulb-crop systems (**chlorine dioxide studies**) Washington State University FY 2005-06: Assess effectiveness of chlorine dioxide as a cut flower and flower bulb treatment to control diseases caused by Penicillium, Fusarium, Botrytis and other pathogens (milestone 2d). FY 2005-06: Determine the safety of chlorine dioxide treatment with regard to bulb growth and flower quality (milestone 2d).

The host ranges of selected species of **Pythium** will be explored in collaboration with Cornell University researchers (milestone 1b). FY 2005-07: **Resistant isolates** will be characterized using total DNA analyses and traced to their point of origin within greenhouses. DNA sequences correlated with fungicide resistance will be sought. Experiments will be completed to show a 'hormesis effect' from mefenoxam and propamocarb fungicides. This effect is manifested as greater disease development in the presence of very low concentrations of fungicides than occurs in the absence of fungicide. Low concentrations of fungicides often occur as greenhouse irrigation water is recycled and diluted. Case studies will be undertaken in 06-07 to trace the origin of fungicide-resistant isolates (milestone 1c). FY 2006-07: Total DNA analyses will be done to determine whether selected insects are significant vectors of Pythium in greenhouses. (G. Moorman and doctoral candidate C. Garzon) have found a hormesis effect (in which disease symptoms are increased in the presence of very low levels of fungicide) of propamocarb and mefenoxam on Pythium. Although, in the past, low levels of chemicals have been considered to increase the speed with which pesticide resistance develops, there has been no indication until now that low levels of certain fungicides used for root rot management in the greenhouse might actually increase disease

Fungicide Resistance Detection and Characterization: Fungicide-resistant pathogen populations were identified in greenhouses. This included the first report of resistance to propamocarb and multiple resistance to propamocarb and mefenoxam in an Oomycete. Identification of a high level of mefenoxam/metalaxyl resistance in flower crop greenhouse Pythium populations has underscored the need for grower education to reduce over-reliance on this chemistry and for trials of alternative products and methods to improve disease management. Highly mefenoxam-resistant strains of Pythium were detected in greenhouse water-holding tanks, suggesting that irrigation system holding tanks could provide a reservoir of resistant strains.

Alternatives to Formaldehyde for Disease Control: Formaldehyde has previously been the industry standard for bulb treatment to reduce disease losses, but its toxicity and identification as a carcinogen make it an undesirable pest management tool. Chlorine dioxide has been demonstrated to be a useful alternative to formaldehyde for control of flower bulb diseases.

DISEASE NOTE

FIRST REPORT OF TURNIP MOSAIC VIRUS IN LILY

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In the Lazio region (southern Italy) some lilies (*Lilium* spp.) of a pink cultivar showing flower breaking were found to be infected by Turnip mosaic virus (TuMV) (genus Potyvirus). The virus, which was not sap transmitted to herbaceous hosts, was abundantly observed in leaf-dip preparations of symptomatic flowers. Our isolate of TuMV from lily flowers did not react in ISEM and GLAD with antisera obtained from the Bulb Research Centre, Lisse, The Netherlands, to the potyviruses Tulip breaking virus (TBV) and Lily mottle virus (LiMV). The literature on potyviruses that cause flower breaking in tulip (Tulipa spp.) and lily, reports that Tulip top-breaking virus (TTBV) is a strain of TuMV and does not cross-react with TVB and LiMV (Dekker et al., 1993), which tallies with our serological results. The occurrence of TuMV in lily shows the need of further investigation on the serological relationships among the potyviruses causing colour breaking in lily and tulip.

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CHECK

Topsin Summer Drench
Replicate #2 of all 5 test treatments (Check, Subdue, Banol 2 Qt, Banol 1 Qt, Busan) had substantially lower vigor and more "downer" spots in June 2002. This entire replicate was treated with Topsin at 4.5 # AI/A (1 gallon per acre of Systec 1998) on August 5th. The Systec was sprayed as a band over the tops of the plants and then washed in with a 12-hour sprinkler set.
This treatment improved yield and harvest foliage condition when combined with both Banol rates. It also improved foliage condition when combined with Subdue, but did not increase yield. It did not improve foliage or yield with checks or Busan.
Remember however that this replicate #2 looked the worst of all reps in spring crop vigor and the presents of "downer" areas before this treatment was applied.

Busan has a history of potential phytotoxicity when used as a bulb dip. The last two trials have tested Busan as a furrow spray and found phytotoxicity to be reduced. Two years yield figures show Busan to yield similarly to untreated checks. Busan can cause stunting at a 2 Qt rate (2001 data). Busan plots showed some "downer" spots in 2002. Busan treated bulbs had slightly better root systems than the checks, and the addition of summer applied Topsin did not result in root system improvement. The adjusted (for row position) yield of Busan plots were consistently above average.

CONCLUSIONS

Busan (Marketed by Wilber Ellis as Nusan) is a benzothiazole compound somewhat similar to Benlate or Topsin –M. It has activity on Pythium, Rhizoctonia, and to some degree nematodes. It has been tested here at the station on lilies over the 15 years as a bulb soak, with indication that it has efficacy and also potential phytotoxicity. Although it is registered on Gladiolus corms as a soak, its use on lilies has been held back by potential phytotoxicity.

This trial attempted to reduce phytotoxicity by making application to the furrow after bulbs were planted instead of a direct soak of the bulbs. This trial shows that phytotoxicity is still a potential problem with the furrow application method. The 1 Quart dose was one of the better treatments in this trial with the highest bulb survival and the lowest "Downer" percentage. However, the 2 Quart treatment had the lowest bulb survival, the lowest bulb size, and the highest number of "roughed" and "downer" bulbs. This is an effective product with low plant tolerance for overdosing.

Subdue once again provided very good control of Pythium in this trial. This was the first trial since 1996 to show any "downer bulbs" in any Subdue treated plots. Commercial growers (who have been using Subdue since 1997) also remarked that they had a few spots of "downer" bulbs in Subdue treated fields for the first time ever in 2001.
One of the potential disadvantages to the prolonged use of Subdue in other crops is pathogen resistance, known to be associated with this product.
Field grown Easter lily bulbs are sold to our greenhouse customers who in turn use Subdue in the pot-forcing phase of production. If we were to develop Subdue resistant strains in the field-growing phase it could affect our greenhouse customers ability to grow a quality finished

product. Our infrequent application schedule (One field application on a rotational field every several years) should slow resistance pressure on the soil born population, but it is likely that the Pythium population carried into a field on the bulb root systems could receive multiple (3) Subdue applications over several (3) years. Resistant Pythium could then be spread in the water based bulb dipping tanks and washing tanks to the planting stock, which could then re-infest the field soil.

Another recent puzzle that showed up in this trial (as well as in commercial plantings) is the increasing numbers of bulbs with corky rusty brown rot “Rusty Crud” syndrome that has been identified by 5 different labs as “an unusual form of Fusarium Oxisporum and or Solanii”. My personal feeling is that the use of biocidal fumigants (such as Metam or Methyl Bromide) to replace nematicidal fumigants (Telone) over the last decade (largely due to regulations by the state) has led to the elimination of unknown beneficial organisms that controlled both Pythium and Fusarium to a large extent.

First we faced the new “Upper Downer” disease, determined it was caused by Pythium, and fought back with Subdue after a series of trials showed Subdue was the most efficacious of the chemical and biological treatments tested.

“Rusty Crud” (Fusarium) was also increasing slowly in these “biocide” fumigated fields at the same time. The unanswered question I now have after observing this last season is “Does Subdue somehow stimulate development of “Rusty Crud”?

Subdue has become the “state of the art” Pythium control material on lilies since 1997 and is being used on most commercial acreage. Cost per acre is in the range of $85 to $170.

Fusarium “rusty crud” symptoms were the worst in fall of 2001 after outdoor un-shaded air temperatures reached 103 Sept 18th, 116 Sept 19th and 118 on Sept 20th 2000 (when the crop was planted). We set a new 23 year high soil temperature record the third week of September 2000 of 74.5 degrees at 6” depth. That was 10 degrees above average. Rows that were being planted at the Station on those days under high heat conditions showed much higher symptoms at digging. Excessive fertilizer also seems to be involved in the increase of “rusty crud” Fusarium symptoms. One row with a 2X dose of bottom fertilizer that got mixed into the bulb planting area had 100% Fusarium symptoms in 2000. It appears that bulb damage from desiccation also enhances Fusarium damage. Also more Fusarium symptoms have also shown up in bulb cooking trials (UCDavis) and metam in furrow trials (ELRF). My premise is that any kind of “heat” damage (from cooking, fertilizer salts, metam residues, hot soil or shed temperatures) can trigger Fusarium damage.

Past experience has shown that furrows that are too wet or overly compacted when planted will increase **Pythium** symptoms the next year. Loosening furrows is a method of cultural control. The furrows in the 2002 trial were loosened.