

Canker Control Trials in Florida for Grapefruit and Hamlin Orange, 2008

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Introduction

Control of citrus canker in Brazil and Argentina is based on an IPM approach that foremost relies on planting of resistant varieties. In Florida, the fresh fruit and processing industries are heavily based on highly susceptible grapefruit and moderately susceptible Hamlin orange, respectively, which makes it necessary to rely more on other IPM measures. In South America this includes the use of windbreaks and bactericidal copper sprays to suppress the bacterium and prevent spread to non-infested areas. Kocide 2000 at rates as low as 0.5 lb metallic copper per acre is effective for reducing fruit disease and premature drop on moderately susceptible orange varieties in Brazil. Testing of copper formulations and rates in Florida is crucial to determine the efficacy of copper programs for control of the disease on grapefruit to qualify them for movement to the packinghouse for shipment as asymptomatic fruit or to reduce premature fruit drop of early oranges to minimize yield losses. In the case of fresh grapefruit this means that canker disease levels on fruit should not exceed 5% in the grove and should be reduced by pre-selection to 1% or less when entering the final packing process. Major questions for grapefruit are 1) can this level of control on grapefruit be achieved without windbreaks, 2) how long through the season will it be necessary to spray to protect the fruit, For early oranges the questions are what rates and duration of sprays are effective to minimize the amount of copper applied per acre season to reduce costs. Higher rates and longer durations of copper sprays risk phytotoxicity to fresh fruit, induction of copper resistance in the pathogen, soil accumulation and environmental contamination by copper. The purpose of these trials on grapefruit and Hamlin orange is to complete the initial assessment of canker control for fresh grapefruit in an east coast grove and Hamlin orange in a south central grove.

Experimental approach:

Objective1: To define rates and formulations for effective control of canker on grapefruit and Hamlin orange,

Approach to the objective:

Grapefruit trial

Location: Ft. Peirce, St. Lucie County

Citrus variety: 6- yr-old Red grapefruit

Tree spacing: 12 ft x 25 ft spacing; 145 trees per acre

Randomized complete block: 4 plots of 5 trees/plot (5 trees in a row, 20 trees per treatment). Each plot is approx 0.137 acres.

Spray volume and application: One gallon of spray per tree applied with a handgun (to incipient run-off from foliage) @ 20 gal per treatment equivalent to 145 gal/acre

Spray interval: every 21 days from mid March to Early October

Spray dates: 3/7; 3/28; 4/18; 5/9; 5/30; 6/20; 7/11 (Firewall spray); 8/4 (Firewall spray); 8/26; 9/15; 10/6; 10/27

Disease evaluations:

Fruit drop: all fruit on the ground under the middle 3 trees in each plot was periodically collected and evaluated for cause of fruit drop and fruit diameter is measured to determine the size of the fruit when was infected and dropped.

Fruit disease: Prior to harvest incidence of fruit with canker lesions, the age of the lesions and severity of lesions was assessed on 100 fruit collected from the middle 3 trees in each plot. Lesions are classified as “old” if they are larger than 0.25 inches in diameter, coalescing with surrounding lesions, black in color, exuding gum or have a prominent yellow halo; and “young” if lesions are smaller than 0.25 inches in diameter, brown in color, and not coalescing with surrounding lesions. Copper phytotoxicity, citrus scab (*Elsinoe fawcetti*) and melanose (*Diaporthe citri*) lesions on the fruit will be noted if present.

Table 1: Formulations, rates and manufacturers of products tested in the grapefruit trials

Treatment	Manufacturer /supplier	Metallic Cu (%) or a.i.(%)	Rate (lbs/acre)	Metallic Cu/acre
Kocide 2000	Dupont	35	2.0	0.66
Kocide 3000	Dupont	30	2.0	0.60
Kocide 3000	Dupont	30	1.0	0.30
Cuprofix Ultra 40	United Phosphorus	40	1.5	0.60
Kocide 3000 - Firewall(2x)- Kocide	Dupont/ Agrosource	30/ 22.4	2.0/ 1.5	0.60
Kocide 3000 - Firewall(2x)- Kocide plus 435 spray oil	Dupont/ Agrosource	30/ 22.4	2.0/ 1.5 5 gal/acre	0.60
Kocide - Firewall + Kocide (2x) - Kocide	Dupont/ Agrosource	30/ 22.4	2.00 1.5/1.00	0.60 0.30
Kocide 3000 +PDS*	Dupont	30	2.0 0.05gal/ac	0.60
Champ DP	Nufarm	37.5	1.6	0.60
Kentan DF	Isagro	40	1.5	0.60
Badge SC	Isagro	20	2.11 pt/ac	0.60
IRF070	Isagro	28	2.14	0.60
Untreated check	--	--	--	--

*PDS = Polymer delivery system (Smart Anti-microbial Solutions, LLC)

Table 2: Rainfall at Ft. Pierce 2008

Monthly rainfall (inches)	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Ft. Pierce 2008	2.58	0.03	3.48	8.61	12.24	16.87	4.59	4.77	1.15
Ft. Pierce ^z average	2.54	1.89	2.82	6.45	5.22	6.27	7.09	4.59	2.52

^z Average monthly rainfall from 1998-2007 obtained from the Florida Automated Weather Network at IRREC.

Hamlin orange trial

Location: Hardee County

Citrus variety: 6-year old Hamlin

Tree spacing: 12 ft x 25 ft spacing, 145 trees per acre

Randomized complete block: 4 plots of 5 trees/plot (5 trees in a row, 20 trees per treatment). Each plot is approx 0.137 acres.

Spray volume and application: 8 applications by speed sprayer @ approx.160 gal/acre using speed sprayer because of larger canopy volume

Spray interval: every 21 days from mid April to September.

Spray dates: 4/29; 5/21; 6/12; 7/3; 7/21; 8/13; 9/1; 9/24

Disease evaluations:

Fruit drop: all fruit on the ground under the middle 3 trees in each plot was periodically collected and evaluated for cause of fruit drop and fruit diameter is measured to determine the size of the fruit when it was infected and dropped. Fruit drop counts were performed in 6/4, 7/23, 8/20, 9/17.

Fruit disease: Prior to harvest incidence of fruit with canker lesions, the age of the lesions and severity of lesions was assessed on 100 fruit collected from the middle 3 trees in each plot. Lesions are classified as “old” if they are larger than 0.25 inches in diameter, coalescing with surrounding lesions, black in color, exuding gum or have a prominent yellow halo; and “young” if lesions are smaller than 0.25 inches in diameter, brown in color, and not coalescing with surrounding lesions.

Table 3: Formulations, rates and manufacturers of products tested in the Hamlin trials

Treatment	Manufacturer /supplier	Metallic Cu (%) or a.i.(%)	Rate (lbs/acre)	Metallic Cu/acre
Kocide 3000	Dupont	30	2.0	0.66
Kocide 3000	Dupont	30	1.5	0.48
Kocide 3000	Dupont	30	1.0	0.30
Cuprofix Ultra 40	United Phosphorus	40	1.75	0.70
Cuprofix Ultra 40	United Phosphorus	40	1.5	0.60
Cuprofix Ultra 40	United Phosphorus	40	1.13	0.45
Champ DP	Nufarm	37.5	1.6	0.60
Kentan DF	Isagro	40	1.5	0.60
Badge SC	Isagro	20	2.11pt/ac	0.60
IRF070	Isagro	28	2.14	0.60

Cuproraxt		27	10 oz	0.45
Kocide 3000 + Byotrol*	Dupont	30	1.0 7.28oz/gal	0.30
Magna-Bon	Chelated copper	5	0.63	0.03
Untreated check	--	--	--	--

* Byotrol is a disinfectant/cleaner (Byotrol, Inc. USA)

Table 4: Rainfall in Hardee Co. 2008 (site is approx. 20 mile west of Sebring)

Monthly rainfall (inches)											
	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.		
Sebring 2007	4.80	4.15	0.39	9.77	7.78	11.84	3.78	3.26	0.36		
Sebring ^z average	1.51	2.09	2.37	8.84	7.48	7.64	7.00	3.06	1.32		

^z Average monthly rainfall from 2003-2007 obtained from the Florida Automated Weather Network at Sebring.

Objective 2: Establish the period of fruit susceptibility for grapefruit and early oranges

Approach to accomplish the objective:

The duration of fruit susceptibility to canker infection will be established by applying an increasing number of 21 day interval sprays to protect fruit through each stage of growth. In the grapefruit trial, the size of fruit when they become completely resistant to infection will be determined. In the orange trial, the size of fruit when infections of lesser incidence and severity occur but are no longer able to induce premature fruit drop will be determined. For grapefruit, the sprays began at Spring flush (early March) to control early season inoculum build-up on the leaves. In oranges the sprays will begin when fruit are 0.5-0.75 inches in diameter, the size at which the stomates open on the fruit surface.

Grapefruit Trial - Ft. Pierce

Protocol same as under Objective 1

All apps with Kocide 3000 @ 2.0 lbs/acre

Treatments:

1st application in early March (3/7), 2nd app in late March (3/28), 3rd app Mid April (4/18), 4th app early May (5/9), 5th app late May (5/30), 6th app mid June (6/20), 7th early July (7/11), 8th app early August (8/4), 9th app late August (8/26), 10th app - mid Sept. (9/15), 11th app early Oct. (10/7), Untreated Check

Hamlin trial – Hardee County

Protocols same as under Objective 1

All apps with Kocide 3000 2.0 lbs/acre

Treatments:

1st app in late April (4/29) , 2nd app mid May (5/21), 3rd app early June (6/12), 4th app early July (7/3), 5 apps - one additional spray in late July (7/21), 6 apps - one additional spray in mid August (8/13), 7 apps - one additional spray in early Sept. (9/1)

Results

Objective1: To define rates and formulations for effective control of canker on grapefruit and Hamlin orange,

Grapefruit

Fruit drop

Because copper sprays started in early March and rainfall was very low in April-May (Table 2) during the early stages of fruit growth ($\frac{3}{4}$ inch diameter), early season infection of fruit was minimal and fruit drop due to canker infection did not occur season long.

Fruit infection

Prior to Tropical Storm Fay on August 20-22, disease incidence on fruit in our field trials of 6-year-old red grapefruit was 10-20% for copper sprays applied at 21-day intervals compared to 35% in the nonsprayed treatment (Fig. 1). Post TS Fay, disease incidence on fruit increased to 30-40% on copper-treated trees and to 80% in the non-treated trees. The protective film of copper, regardless of rate and formulation, was almost completely overcome by the windblown rain from TS Fay. When canker bacteria are driven by rain droplets at speeds greater than 18 mph, they impact fruit and leaf surfaces and move past the copper film into stomates where they cause infection.

All copper treatments were effective in reducing canker incidence on fruit compared to the untreated check (UTC) (Fig. 1). None of the copper treatments gave significantly better control than the others although some trends can be noted. At the 2.0 lb/acre rate Kocide 3000 gave better control than Kocide 2000 at the equivalent rate. The 2.0 lb rate of Kocide 3000 performed better than the 1.0 lb rate. Treatments of Kocide 3000 at the 2.0 lb rate followed by two July applications Firewall alone, with oil, or with a 1.0 lb rate of Kocide produced the lowest total incidence of fruit disease. PDS with Kocide 3000 at the 2.0 lb rate did not perform better Kocide alone.

Hamlin

Fruit drop

Before copper sprays were initiated, infection of Hamlins occurred during the early rains of April of 1 to 2 inches. The infection of very small fruit ($\frac{1}{4}$ - $\frac{1}{2}$ inch diam.) resulted in a 40-70% increase of premature fruit drop in May (June 4 reading -Fig. 2). Copper sprays did little to reduce the rate of fruit drop due to early season infection of fruit. In July, 75% of the fruit drop was due to canker while in spray treatments drop due to canker ranged from 50-80%. In August and September, nearly 100% of the fruit drop was due to canker irrespective of treatment. Overall, disease control with copper applied after the early April rains and fruit infection was highly compromised for the remainder of the season.

Cumulative fruit drop due to canker was reduced by spray treatments with different copper formulations (Fig. 3). Although the reduction in drop was not statistically significant, the numerical reduction was substantial and varied from 25-75%. The estimated loss of fruit in the UTC trees was approx. 1.0 90 lb. box/tree and on average the copper treatments reduced fruit drop to approx. 1/3 box/tree. Based on a 5 box per tree production for the 6 year old Hamlins, the estimated yield loss in the UTC trees was 16% and the loss reduced to the 5% by copper treatments.

Fruit infection

The response to treatments of canker infected fruit was similar to that of fruit drop. Copper sprays reduced fruit infection but not significantly (Fig. 4). Treatments with lower fruit infection were those that had a greater number of plots protected from winds coming from the southeast direction. This explains why the treatments with lower rates of Kocide 3000 and Cuprofix outperformed the same formulations at higher rates. Magnabon, a chelated copper formulation, performed as well as the other standard copper formulations at a much lower rate of copper per application. Addition of the disinfectant Byotrol with the 1 lb/acre rate of Kocide 3000 did not produce disease control greater than that of the Kocide 3000 alone.

Objective 2: Establish the period of fruit susceptibility for grapefruit and early oranges

Grapefruit

Irrespective of the number of sprays of Kocide 3000 at the 2.0 lb rate, because of the impact of TS Fay, the difference in new lesions among treatments was minimal (Fig. 5). In contrast sprays applied pre TS Fay gave progressively better control with increasing number of sprays whereas after TS Fay the effect of additional sprays was minimal.

Hamlin

Sprays of Kocide 3000 at the 2.0 lb rate did little to reduce the rate of fruit drop due to early season infection of fruit. In July, 45-55% of the fruit drop was due to canker in spray treatments as well as the untreated check (Fig. 6). In August -October, nearly 100% of the fruit drop was due to canker irrespective of treatment. Overall, disease control with copper applied after the early April rains and fruit infection was highly compromised for the remainder of the season. Cumulative fruit drop due to canker was not reduced by spray treatments with different copper formulations (Fig. 7).

Because of the early season infection of fruit in April the benefit of applying additional sprays was not seen. Canker incidence on fruit varied from 30 to 45 % irrespective of the number of sprays compared to 50% incidence in the untreated check (Fig. 8).

Conclusions

- 1) Copper products are moderately effective for control of canker on fruit of highly susceptible grapefruit

- 2) TS Fay rendered all treatments ineffective for control due to overcoming of the film on the fruit surface by windblown rain. Firewall applied in July in advance of TS Fay gave somewhat more effective control than copper alone. This activity was seen as less incidence of fruit infection immediately after TS Fay. This is attributed to the ability of Firewall to become locally systemic and reduce the no. of post penetration infections.
- 3) Kocide 3000 at 2.0 lb performed better than an equivalent rate of Kocide 2000 and the higher rates were slightly more effective than the lower rate. This confirms the greater efficiency of this newer formulation compared to Kocide 2000. This was also observed in the 2007 grapefruit trial.
- 4) Polymer Delivery System (PDS), an adjuvant, did not increase the efficacy of Kocide 3000.
- 5) Best treatments reduced canker incidence on fruit to no lower than about 27%. This means that windbreaks are essential to sustain disease control on grapefruit for the fresh market
- 6) Infection of Hamlin fruit of ¼ to ½ inch diameter occurred during early April rains of unusually high wind intensity before copper sprays commenced in late April.
- 7) After early season infection of Hamlin, the subsequent season long sprays with copper formulations did not significantly reduce the incidence of canker on fruit and were only moderately effective for reducing fruit drop due to canker throughout the season.
- 8) Magnabon, a chelated copper formulation, performed as well as the other standard copper formulations at a much lower rate of copper per application.
- 9) Byotrol with the 1 lb/acre rate of Kocide 3000 did not produce disease control greater than that of the Kocide 3000 alone.

Recommendations

Evaluation of copper formulations for control of fruit disease and fruit drop on Hamlin should be initiated earlier to control infection on fruit from ¼ to ½ inch diameter. Evaluation of Firewall should target the limited number of sprays in July in advance of the highest of risk of tropical weather. Well-timed Firewall applications may reduce infection post penetration as well as reduce the risk of copper burn.

Ft. Pierce Experiment 1
November 2008

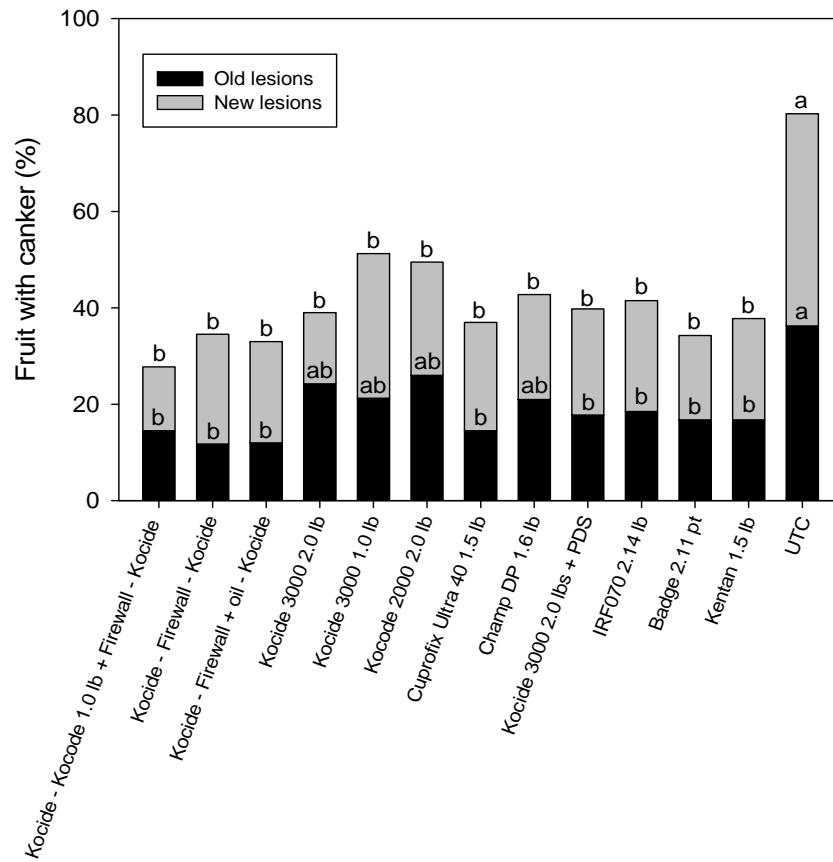


Fig. 1. Effect of sprays of copper formulations and Firewall on total canker incidence on fruit, and old lesions (pre TS Fay) and new lesions (post TS Fay) on fruit of 6 yr-old grapefruit trees at Ft. Pierce, FL in 2008

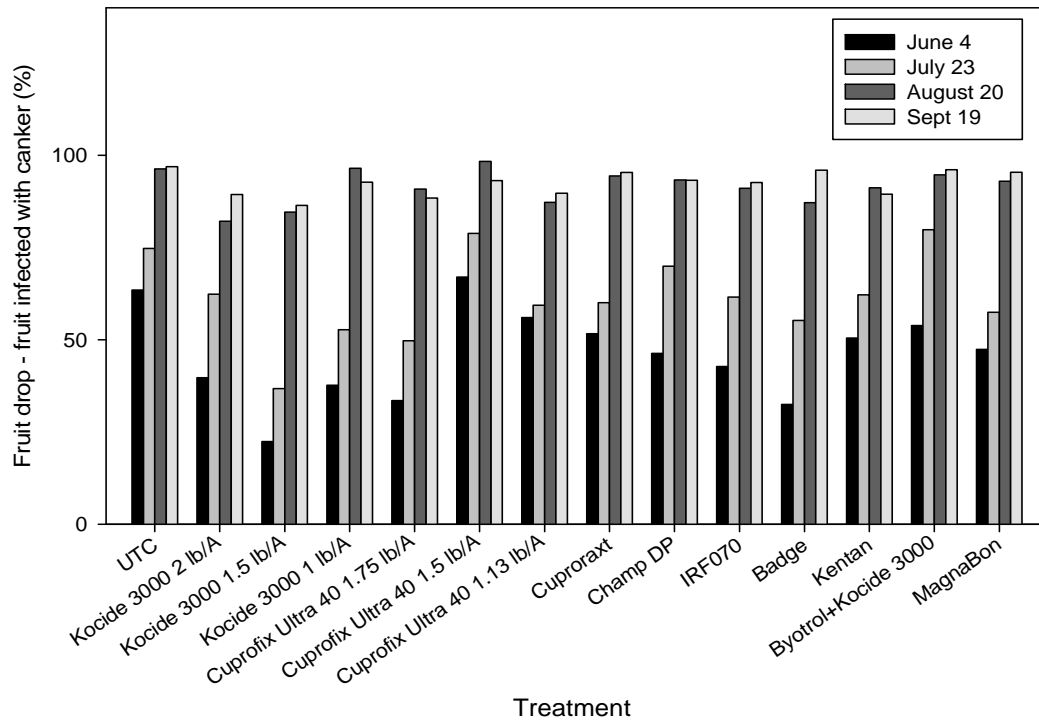


Fig. 2. Effect of sprays of coppers and other products on percentage of canker-induced fruit drop from June - Sept for 6 yr-old Hamlin trees at Hardee county, FL in 2008

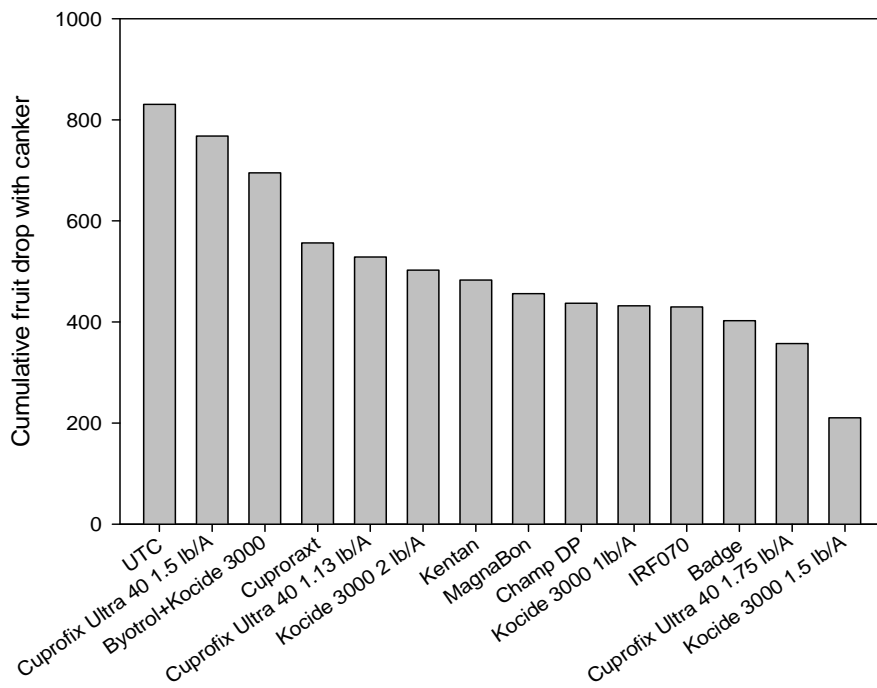


Fig. 3. Effect of applications of Kocide 3000 through the season on cumulative number of fruit dropped due to canker from June to September for 6 yr-old Hamlin trees in Hardee county, FL in 2008

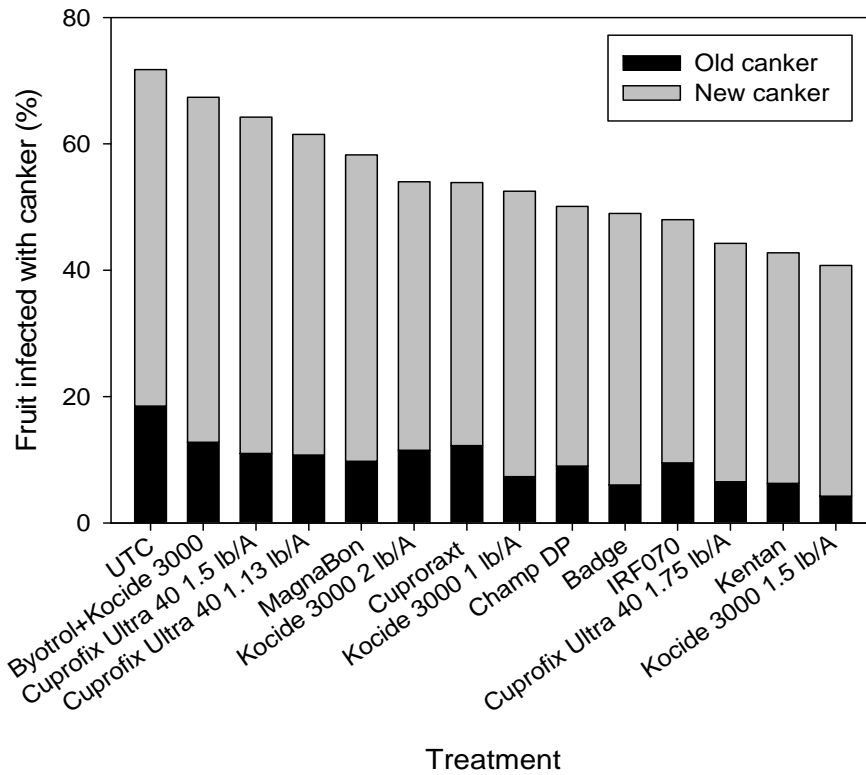


Fig. 4. Effect of sprays of coppers and other products on total canker incidence on fruit, and the old lesions (pre TS Fay) and new lesions (post TS Fay) on fruit of 6 yr-old Hamlin trees at Hardee county, FL in 2008

Ft. Pierce Experiment 2
November 2008

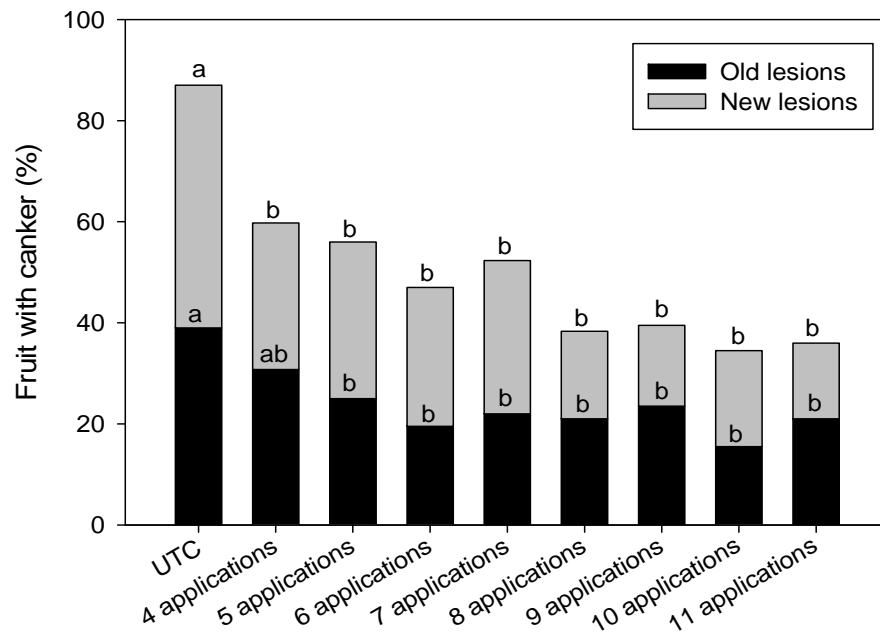


Fig. 5. Effect of sprays of Kocide 3000 on total canker incidence on fruit and on the early (old) and late season (new) lesions for 6 yr-old grapefruit trees in Ft. Pierce, FL in 2008

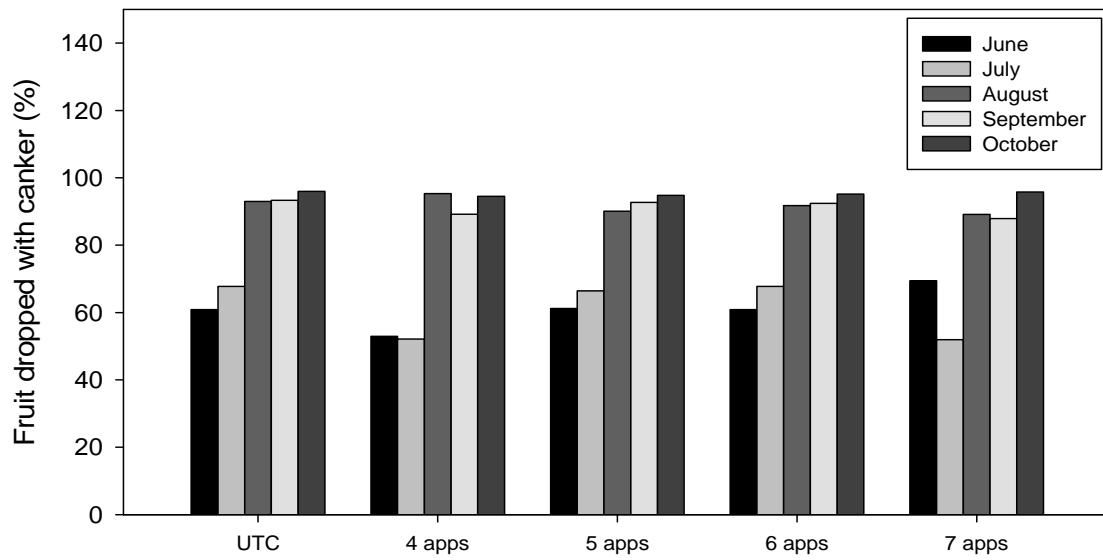


Fig. 6. Effect of sprays of coppers and other products on percentage of canker-induced fruit drop from June - October for 6 yr-old Hamlin trees at Hardee county, FL in 2008

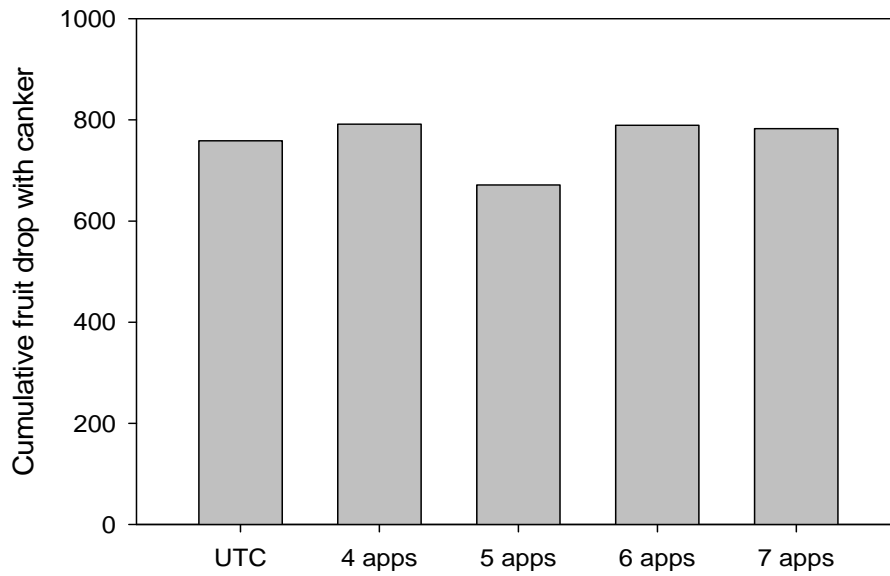


Fig. 7. Effect of applications of Kocide 3000 through the season on cumulative number of fruit drop due to canker from June to October for 6 yr-old Hamlin trees in Hardee county, FL in 2008

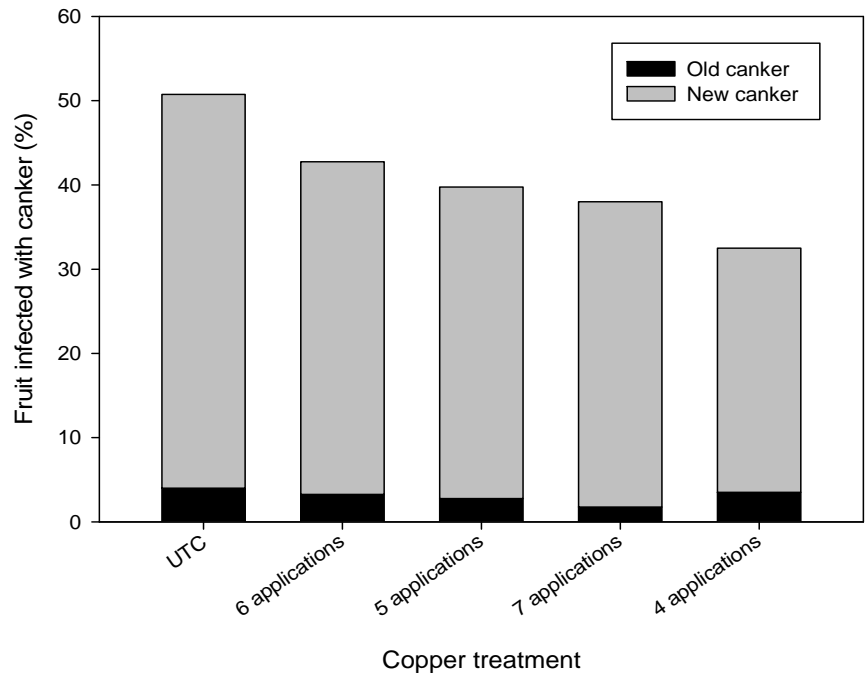


Fig. 8. Effect of applications of Kocide 3000 through the season on canker incidence on fruit for 6 yr-old Hamlin trees in Hardee Co., FL in 2008