Increasing N rates had little effect on tomato yields in the fall. In the spring, increasing N rates increased number of cull fruits in the first pick (Table 7) and in the total harvest for both lines (Table 10). Number of cull fruits increased with increased N rates regardless of K rates or cultivars (Table 8). High N rates reduced fruit weight and number of 5x6, combined 5x6 + 6x6 and marketable yields. The yield reduction with increasing N rates was especially important in the large fruit sizes. For example, increasing the N rate for 'Horizon' from 225 to 450 lb./7500 lbf (from 3 lb. to 6 lb./100 lbf) reduced the seasonal yields of 5x6 and combined 5x6 + 6x6 fruits by 50% (Table 10). The present studies, therefore, provide further confirmation of earlier reports on the adverse effect of high N rates on tomato yield and quality in Florida.

In summary, large differences were found in the yield response of line 7060 and 'Horizon' to K rates in fall and spring. Line 7060 had a greater demand for K than 'Horizon.' Nitrogen rates reduced the marketable yields and increased the cull grade fruits of both tomato lines. Therefore, to maximize yield and quality, 'Horizon' should be grown with low, 225 lb./7500 lbf N and low to medium, 187 to 374 lb. K rates.

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THE EFFECT OF BACTERICIDES, TANK MIXING TIME AND SPRAY SCHEDULE ON BACTERIAL LEAF SPOT OF TOMATO

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Abstract. **Bactericides were compared for control of bacterial spot of tomato (*Lycopersicon esculentum* Mill.), caused by *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye in the field from 1981 through 1984. Various Cu formulations were compared for efficacy. The commercial Cu containing compounds did not differ significantly in control of bacterial spot. Addition of mancozeb to the Cu bactericides increased their efficacy. Cu hydroxide and mancozeb tank-mixed and held for 4 hours did not give any better control of bacterial spot than the Cu-mancozeb combination that was mixed and applied immediately.**

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Bacterial spot of tomato incited by *Xanthomonas campestris* pv. *vesicatoria* (referred to as XCV) is one of the most destructive diseases of tomato (*Lycopersicon esculentum*) in Florida. Control of this disease with bactericides in Florida during periods of high disease pressure often is ineffective. Streptomycin has been quite effective for control of bacterial spot during periods of low disease pressure. However, XCV developed resistance to streptomycin in Florida, and thus reduced the effectiveness as the season progressed (6). Cu compounds have also been used extensively in Florida. Stall (5) demonstrated that a number of Cu compounds were equally effective for controlling bacterial leaf spot of tomato. Conover and Gerhold (2) reported that Cu sprays, when applied without maneb or mancozeb, were ineffective for controlling XCV. Marco and Stall (4) demonstrated that many of the XCV strains were actually tolerant to Cu, but when the Cu was mixed with maneb, the Cu tolerant strains became sensitive.

Numerous Cu compounds are available for control of XCV including cupric hydroxide, tribasic Cu sulfate, Cu ammonium carbonate, Cu oxychloride sulfate, and Cu salts of fatty and rosin acids. Researchers have compared Cu compounds for control of various diseases such as bacterial speck of tomato (1) and bacterial spot of tomato (6). However, Cu compounds tank-mixed with mancozeb compounds have not been tested for the control of Cu tolerant strains.

There has been a controversy concerning premixing of Cu compounds and mancozeb. It is believed that premixing for a period of time prior to application results in a higher level of soluble Cu which increases the effectiveness of the combination for control of bacterial leaf spot.

The objectives of this study were to compare various Cu bactericides applied alone or in combination with mancozeb and several other bactericides for control of bacterial leaf spot, to compare tank mixing times of Cu-maneb mixtures to determine if period of mixing affects control of bacterial leaf spot, and finally, to study the frequency of application in order to determine its role in control of bacterial leaf spot.

Materials and Methods

'Sunny' tomato transplants were set in the field onto raised black polyethylene mulch covered beds. The experimental plots in each study consisted of randomized complete block designs. All fungicide:bactericide treatments were applied using a 2-gal stainless steel sprayer with 40 psi.

Bactericides and fungicides tested. The following fungicides and bactericides were used in these studies: Cupric hydroxide, (Kocide 101 and CP blue basic, 50% Cu), fixed Cu (CP, Phelps Dodge, and Tennessee Copper's basic Cu sulfate, 53% Cu), Cu ammonium carbonate (AR 153844 and Copper Count N, 8% Cu), Cu ammonium sulfate (Copac, 3% Cu), Cu oxychloride sulfate (COCS, 50-53% Cu), Cu salts of fatty and rosin acids, (Citcop 4E and 5E, 4% and 5.75% Cu, respectively), streptomycin (Agrimycin), oxytetracycline (Mycoshield), chlorothalonil (Bravo), mancozeb (Dithane M-45 and Manzate 200), DS 64220 (27% cupric hydroxide, 5.4% maneb, 27% chlorothalonil).

Bactericide tests. In Expt. 1 the plants were set 18 inches apart on 14 Oct. 1981. Each treatment consisted of 4 replications with 10 plants per plot. Chemical applications were begun 21 Oct. 1981 and applied at weekly intervals. A bacterial suspension consisting of 2.8×10^9 cells/ounce of XCV was applied to the foliage on 15 Nov. 1981. Plants were visually rated for percent defoliation on 10 Dec. 1981.

In Expt. 2 the plants were set 26 Aug. 1983. The plots consisted of 12 plants spaced 1 foot apart. Bactericidal applications were applied on 1 Sept. 1983 and at weekly intervals until first harvest. The plots were sprayed with 2.8×10^9 cells/ounce of Cu on 2 Sept. and 18 Sept. 1983. Plots were rated for bacterial spot severity on 29 Sept. 1983 by collecting 10 leaflets per plot and rating total leaf area affected.

In Expt. 3 the plants were set 18 inches apart on 7 Mar. 1984. Plots consisted of 12 plants. Weekly applications of treatments were made from 21 Mar. 1984, throughout the experiment. Chlorothalonil was applied on a weekly schedule to all plots at the rate of 1.5 quarts per 100 gal. The plots were sprayed with 2.8×10^9 cells/ounce of XCV on 22 Mar. and 4 Apr. 1984. Disease ratings were made

Table 1. The effect of weekly application of bactericides on bacterial spot severity of 'Sunny' tomato, 1981.

Treatment (lb./100 gal)	Disease severity[z]
Cu hydroxide (Koxide 101) (2) + mancozeb (Manzate 200) (1.5)	2.5 bcd
Cu salt (Citcop 4E (2)[y]) + mancozeb (Manzate 200) (1.5)	4.4 bcd
Tri-Basic Cu Sulfate (Tennessee Copper) (2) + mancozeb (Manzate 200 (1.5))	2.5 bcd
Tri-Basic Cu Sulfate (Tennessee Copper) (3) + mancozeb (Manzate 200 (1.5))	3.5 bcd
Tri-Basic Cu Sulfate (Tennessee Copper) (4) + mancozeb (Manzate 200 (1.5))	3.2 bcd
Cu ammonium carbonate (Copper Count N (2[y]) + mancozeb (Manzate 200 (1.5))	2.5 bcd
Cu ammonium carbonate (Copper Count N (3)[y]) + mancozeb (Manzate 200 (1.5))	4.6 bcd
Cu ammonium carbonate (Copper Count N (3)[y])	5.6 bc
Basic Cu sulfate (Phelps Dodge (3)) + mancozeb (Manzate 200 (1.5)	3.7 bcd
Basic Cu sulfate (Phelps Dodge (4)) + mancozeb (Manzate 200 (1.5)	1.8 bcd
Basic Cu sulfate (Phelps Dodge (3))	5.3 bc
Basic Cu sulfate (CP) (2)	5.4 b
Basic Cu sulfate (CP) (2) + mancozeb (Manzate 200 (1.5))	1.6 cd
Cu hydroxide (CP Blue Basic Cu sulfate (2))	2.9 bcd
Cu hydroxide (CP Blue Basic Cu sulfate (2)) + mancozeb (Manzate 200 (1.5))	2.3 bcd
Control	12.4 a

[z]Figures are mean percentages of defoliation by bacterial leaf spot when rated 10 Dec. 1981. Mean separation in columns by Duncan's multiple range test, 5% level.
[y]Liquid compound with number representing quarts/acre.

Table 2. The effect of bactericides on bacterial spot severity, target spot severity, and yield parameters for 'Sunny' tomato in Fall 1983.

Treatment (rate)	Bacterial spot rating[z]	Fruit number	Fruit wt. (lb.)
Cu hydroxide (Kocide 101) (2 lb.) + mancozeb (Dithane M45) (1.5 lb.)	2.0 b[y]	314.5 a	93.3 ab
Cu ammonium carbonate (AR153844) (2 qts) + mancozeb (Dithane M45) (1.5 lb.)	1.3 b	303.3 a	88.3 ab
Cu hydroxide (CP Blue Basic A (2 lb.)) + mancozeb (Dithane M45) (1.5 lb.)	1.5 b	322.5 a	95.5 ab
Tribasic Cu Sulfate (CP (4 lb.)) + mancozeb (Dithane M45) (1.5 lb.)	2.7 b	328.0 a	97.8 ab
Tribasic Cu sulfate (Tennessee Copper (3 lb.)) + mancozeb (Dithane M45 (1.5 lb.)	2.4 b	357.3 a	107.0 a
Cu salt (Citcop 5E (3 qts)) + mancozeb (Dithane M45) (1.5 lb.)	1.5 b	282.5 a	80.1 b
Cu ammonium carbonate (Copper Count N) (2 qts) + mancozeb (Dithane M45) (1.5 lb.)	1.3 b	382.3 a	93.3 ab
Oxytretracycline (Mycoshield) (1.5 lb.) + chlorothalonil (Bravo) (1.5 qts)	6.4 a	346.8 a	98.7 ab
Oxytetracycline (Mycoshield) (1.5 lb.) + TS 188-30 1200 ppm (1.0 lb.)[x] + chlorothalonil (Bravo) (1.5 qts)	2.3 b	324.0 a	95.9 ab
Streptomycin (Agrimycin) (1.2 lb.) + chlorothalonil (Bravo) (1.5 qts)	1.9 b	339.0 a	103.6 ab
Control (chlorothalonil (Bravo) 1.5 pts)	6.4 a	352.8 a	105.6 a

[z]Rating is percent leaflet area affected.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 3. The effect of various bactericides on bacterial spot severity and yield parameters of 'Sunny' tomato in Spring 1984.

Treatment (rate per 100 gal)	Bacterial spot severity rating[z]			Marketable yield/plant	
	20 Apr.	3 May	21 May	Fruit number	Fruit wt (lb.)
Cu *ammonium carbonate* (Applied research) (2 qt) + mancozeb[y] (1.5 lb.)	1.2 cd[x]	3.5 cd	4.7 ef	26.2 a	7.0 a
Cu ammonium carbonate (Applied research) (3 qt) + mancozeb (1.5 lb.)	0.7 d	5.0 cd	5.3 ef	25.3 a	7.2 a
Cu ammonium sulfate (Copac) (0.3 lb. a.i.)	0.3 d	2.4 cd	4.3 ef	22.5 ab	5.8 ab
Cu ammonium sulfate (Copac) (0.45 lb. a.i.)	0.0 d	4.4 cd	7.2 ef	25.8 a	7.2 a
Cu ammonium sulfate (Copac) (0.45 lb. a.i.) (every other week)	0.4 d	7.7 bcd	9.7 de	23.3 a	6.4 ab
Cu ammonium sulfate (Copac) (0.3 lb. a.i.) + mancozeb	0.0 d	3.1 cd	11.2 cde	25.6 a	7.0 a
Oxytetracycline (Mycoshield) (1.5 lb.)	5.8 ab	9.9 bc	15.1 bcd	25.9 a	7.0 a
Cu ammonium carbonate (Copper Count N) (2 qt) + mancozeb (1.5 lb.)	0.1 d	4.2 cd	7.0 ef	25.8 a	7.1 a
Control	7.0 a	17.3 a	23.4 a	23.4 a	6.2 ab

[z]Rating is percent of plant defoliated by bacterial spot.
[y]Dithane M-45 was the source of mancozeb.
[x]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 4. The effect of weekly applications of bactericides on bacterial spot severity and yield parameters of 'Sunny' tomato in Fall 1984.

Treatment (rate per 100 gals)	Bacterial spot severity rating[z]			Marketable yield/plant	
	17 Sept.	14 Oct.	23 Oct.	Fruit number	Fruit wt (lb.)
Cu hydroxide (Kocide 101) (2)) + Mancozeb[y]	8.1 c-f[x]	6.8 d	6.9 c-f	391.8 b-d	117.9 c-e
Cu hydroxide (Kocide 101) (2)) + chlorothalonil (Bravo)	13.8 a-c	15.2 a	10.8 b-f	380.8 b-d	117.4 c-e
Mancozeb	11.7 a-f	14.7 ab	17.1 a	391.8 b-d	112.7 de
DS-64220 (5)	7.4 c-f	7.4 d	7.8 b-f	405.3 b-d	117.7 c-e
DS-64220 (3)	9.0 b-f	7.9 cd	9.2 b-f	427.8 a-c	129.4 c-e
DS-64221 (5.6)	5.9 f	6.9 d	4.8 f	448.3 ab	137.8 ab
DS-64221 (3.3)	12.0 a-f	9.0 b-d	6.6 d-f	423.5 a-c	131.8 a-d
Chlorothalonil (Bravo (1.5 quarts))	16.8 a	13.9 ab	20.9 a	426.3 a-c	132.0 a-d
Cu ammonium carbonate (Applied Research (2 quarts)	12.0 a-f	14.1 ab	14.2 b	375.8 b-d	111.5 e
Cu ammonium carbonate (Applied Research (2 quarts) + mancozeb	11.5 a-f	8.0 cd	6.4 d-f	406.0 b-d	121.4 b-e
Oxytetracycline (Mycoshield) + chlorothalonil (Bravo)	12.7 a-e	15.2 a	12.6 b-d	418.5 a-c	125.0 b-e
Oxytetracycline (Mycoshield 300 ppm) + Penetrator (1 pt) + chlorothalonil (Bravo)	13.0 a-d	15.7 a	10.8 b-f	427.0 a-c	125.5 b-e
Oxytetracycline (Mycoshield 300 ppm) + Penetrator (2 pt) + chlorothalonil (Bravo)	14.6 ab	12.8 a-c	13.3 bc	411.3 bc	117.0 c-e
117.0 c-e					
Tribasic Cu sulfate (Tennessee Copper (4)) + chlorothalonil (Bravo)	11.7 a-f	10.7 a-d	13.7 b	440.5 ab	134.7 a-c
Tribasic Cu sulfate (Tennessee Copper (4)) + mancozeb	6.2 ef	6.6 d	6.3 d-f	492.0 a	148.2 a
COCS WP (2) + chlorothalonil (Bravo)	16.7 a	12.7 a-c	9.4 b-f	434.5 ab	128.0 b-e
COCS WP (2) + mancozeb	7.1 d-f	6.6 d	5.6 ef	440.5 ab	131.6 a-d
Control—no fungicide	16.7 a	14.9 ab	16.3 a	404.3 b-d	120.8 b-e

[z]Rating is percent of tomato plant by *Xanthomonas campestris* pv. *vesicatoria*.
[y]Mancozeb (Dithane M-45) which was applied at 1.5 lb./100 gal.
[x]Mean separation in columns by Duncan's multiple range test, 5% level.

on the percent defoliation that resulted from bacterial spot.

In Expt. 4 the plants were set 15 Aug. 1984. Weekly bactericidal applications were begun 22 Aug. 1984. Each plot consisted of 12 plants spaced 1 foot apart. Plots were inoculated by spraying a suspension of 2.8×10^9 cells/ounce of XCV on the tomato foliage 25 Aug. 1985. Disease was rated by estimating percent defoliation.

Tank-mixing and spray schedule studies. In Expt. 1 transplants were set at a 12-inch spacing on 18 Aug. 1982. Cupric hydroxide (Kocide 101) and mancozeb (Dithane M45) at the rate of 2.0 lb. and 1.5 lb/100 gal, respectively, were mixed and incubated 0, 2, or 4 hr prior to application. Control plots were sprayed with chlorothalonil. Weekly applications made from 25 Aug. 1982 with a gasoline powered solo sprayer throughout the experiment. The plots were inoculated 26 Aug. 1982 by misting 2.8×10^9 cells/ounce of XCV on the leaf surface. Plants were visually rated for disease on 24 Sept. 1982 by assessing the percent defoliation attributed to bacterial spot.

In Expt. 2 the plants were set at 1-foot spacings 15 Aug. 1984. Three of the bactericidal treatments consisted of tank-mixing Cu hydroxide (Kocide 101 (2.0 lb./100 gal)) and mancozeb (Dithane M-45 (1.5 lb./100 gal)), and applying the combination immediately to the plants. The mixture of Cu hydroxide and mancozeb was applied once per week, twice per week, or on demand. The demand spray consisted of application after each rainfall or at least twice per week. A fourth treatment involved mixing Cu hydroxide and mancozeb at the same rates. The mixture was incubated 4 hr and applied to the plots twice per week. The control plot was sprayed with chlorothalonil weekly. The plots were inoculated on 25 Aug. 1984 by spraying a suspension of 2.8×10^9 cells/ounce of XCV onto the

Table 5. The effect of tank-mixing time prior to application to 'Sunny' tomato plants on control of bacterial leaf spot in Fall 1982.

Treatments	Tank-mix time[z]	Percent defoliation[y]
Cu hydroxide (Kocide 101) + mancozeb	0	7.25
Cu hydroxide (Kocide 101) + mancozeb	2	23.25
Cu hydroxide (Kocide 101) + mancozeb	4	19.25
Chlorothalonil (Bravo)	–	38.5
LSD 5%		18.4

[z]Time in hours the mixture was incubated prior to application.
[y]Percent defoliation of plant attributed to bacterial leaf spot.
[x]Cu hydroxide = Kocide 101; mancozeb = Dithane M-45.

Table 6. The effect of tank mixing time and frequency of application on control of bacterial leaf spot of tomato.

Treatments	Applications per week	Fall 1984 Disease severity (% defoliation) 17 Sept.	23 Oct.
Cu hydroxide (2) + mancozeb[z]	1	9.9 b[w]	5.8 b
Cu hydroxide (2) + mancozeb[y]	2	6.3 c	1.3 c
Cu hydroxide (2) + mancozeb (4 hr tank mix)	2	5.1 c	1.3 c
Cu hydroxide (2) + mancozeb	On demand or 2 times/week[x]	7.3 bc	1.3 c
Control	0	14.3 a	16.3 a

[z]Cu hydroxide = Kocide 101; mancozeb = Dithane M-45.
[y]Cu hydroxide and mancozeb mixed and applied immediately after mixing.
[x]After every rain or at least twice per week.
[w]Mean separation in columns by Duncan's multiple range test, 5% level.

foliage. Disease was rated by estimating percent defoliation.

Results and Discussion

Bactericidal tests. In the fall 1981 study, disease severity was significantly reduced by the bactericides tested (Table 1). There were no significant differences among Cu compounds when they were applied in combination with mancozeb. The Cu compounds when used alone were less effective in reducing bacterial leaf spot than when combined with mancozeb. The only compound where there was a significant difference between Cu alone and in combination with maneb was with tribasic Cu sulfate (CP basic Cu sulfate). Due to a hard freeze, fruit were not harvested from the plots.

All Cu tested in the fall 1983 test had significantly reduced disease compared to the control. No Cu compound was statistically more effective than another Cu compound (Table 2). Oxytetracycline when applied in combination with chlorothalonil and TS 188-30 or streptomycin mixed with chlorothalonil were equal to Cu-containing compounds. Generally, yields were unaffected by the treatments with the exception of Cu salts of fatty and rosin acids and mancozeb where yield (weight) was reduced. Yield losses in that treatment combination were probably attributable to target spot incited by *Corynespora cassiicola.*

In the spring 1984 test, the Cu compounds did not differ significantly in controlling disease. However, they all were significantly better than the control (Table 3). Yield and fruit number were unaffected by any of the treatments.

In the final test of Fall 1984, all Cu compounds when applied in combination with mancozeb were equally effective in controlling bacterial leaf spot (Table 4). In general, the Cu compounds when applied without mancozeb were statistically less effective in reducing bacterial leaf spot than the Cu-mancozeb combinations. One treatment, tribasic Cu sulfate, had a significantly higher yield than the no fungicide or bactericide treated plots.

Tank-mixing and spray schedule studies. Premixing Cu and mancozeb for up to 4 hr had no effect on bacterial leaf spot control (Tables 5 and 6). These data are in contrast to information that tank-mixing time prior to application is critical to increased efficacy of the mix (3). Applying Cu-mancozeb twice per week resulted in significantly better disease control than 1 application per week.

Commercial compounds containing Cu have for the most part been shown to be equally effective in controlling bacterial leaf spot diseases of tomato (1,6). However, there are exceptions to this where certain Cu compounds have been less effective (1). In our studies, all the commercially available Cu compounds and the experimental compounds were effective in controlling bacterial leaf spot when applied in combination with mancozeb.

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