Table 1. Effect of combinations of magnesium and copper on the growth[z] of *Xanthomonas campestris* pv. *vesicatoria in vitro.*

Copper (ppm)	Copper sensitive strain			Copper resistant strain		
	Magnesium (ppm)					
	0.25	2.5	25	0.25	2.5	25
0.0	61[y]	49	25	49	181	285
0.317	58	104	186	44	173	262
1.0	20	51	112	55	114	324
3.17	9	7	37	54	132	351
10.0	8	7	9	30	90	266

[z]Expressed in optical density units, O.D. x 10^3, 1 cm light path at 625 nm.
[y]LSD, 5% level for within table means: copper sensitive strain = 32; copper resistant strain = 74.

inferior due to a Cu deficiency while 1, 3.17 and 10 ppm Cu were inhibitory to XCV growth. With 25 ppm Mg, 0 ppm Cu was again inferior in XCV growth support to 0.317 ppm Cu, the best Cu level; higher Cu levels inhibited growth.

The Cu resistant XCV did not respond differentially to Cu levels at the 0.25 ppm Mg level which was below the optimum for Mg nutrition. With 2.5 ppm Mg, a growth inhibition to Cu was expressed at 10 ppm Cu relative to 0, 0.317 ppm Cu but not at the other levels. With 25 ppm Mg, the 3.17 ppm Cu level produced the most growth of XCV while the lower levels of Cu appeared to be too low for XCV response; 10 ppm Cu was slightly inhibitory.

The Cu-sensitive XCV strain apparently represents a biotype that is more responsive to Cu than the resistant strain since the sensitive strain was affected more by very low as well as moderate and high levels of Cu. The Cu-resistant strain was little affected over a relatively wide range of Cu. The sensitive strain, due to its greater requirement for Cu could also be termed Cu-inefficient.

The sensitive strain receiving 25 ppm Mg grew better with 0.317 than 0 ppm added Cu, possibly reflecting an induced Cu deficiency. With 0.25 and 2.5 ppm Mg, Cu reduced growth at 3 levels, namely 1.0, 3.17, and 10.0 ppm Cu. At 25 ppm Mg, however, growth was reduced only at 3.17 and 10 ppm Cu. The Cu-resistant strain did not respond very much to Cu at 0.25 ppm Mg because Mg supply limitations produced a relatively standard growth rate; there was, however, a slight suppression at 10 ppm Cu, the highest level. With 2.5 ppm Mg the highest Cu level, 10 ppm, suppressed growth. At 25 ppm Mg there appeared to be interactions that produced best growth at 3.17 ppm Cu with significant growth reductions at 0.317 and 10.0 ppm Cu.

Literature Cited

1. Conover, R. A. 1981. Mixtures of copper and maneb or mancozeb for control of bacterial spot of tomato and their compatibility for control of fungus diseases. Proc. Fla. State Hort. Soc. 94:154-156.
2. Cook, A. A. and R. E. Stall. 1982. Distribution of races of *Xanthomonas vesicatoria* pathogenic on pepper. Plant Dis. 66:388-389.
3. Jones, J. B., S. S. Woltz, and J. P. Jones. 1983. Effect of foliar and soil magnesium application on bacterial leaf spot of peppers. Plant Dis. 67:623-624.
4. Kolthoff, I. M. and E. B. Sandell. 1948. Textbook of quantitative inorganic analysis. The MacMillan Co., New York.
5. Marco, G. M. and R. E. Stall. 1983. Control of bacterial spot of pepper initiated by strains of *Xanthomonas campestris* pv. *vesicatoria* that differ in sensitivity to copper. Plant Dis. 67:779-781.
6. Olson, B. D. and A. L. Jones. 1983. Reduction of *Pseudomonas syringae* pv. *morsprunorum* on Montmorency sour cherry with copper and dynamics of the copper residues. Phytopathology 73:1520-1525.
7. Starr, M. P. 1946. The nutrition of phytopathogenic bacteria. I. Minimal nutritive requirement of the genus Xanthomonas. J. Bacteriol. 51:131-143.
8. Weinberg, E. D. (ed.). 1977. Microorganisms and minerals. Marcel Dekker, Inc. New York.
9. Woltz, S. S. and J. P. Jones. 1979. Effects of magnesium on bacterial spot of pepper and tomato and on inhibition of *Xanthomonas vesicatoria.* Plant Dis. Rptr. 63:182-184.
10. Woltz, S. S., J. B. Jones, and J. P. Jones. 1983. Effects of magnesium on bacterial leaf spot of pepper. Bradenton AREC Res. Rpt. BRA1983-15.

Proc. Fla. State Hort. Soc. 100:222-224. 1987.

REDUCTION IN THE CONTROL OF COMMON NIGHTSHADE (*SOLANUM AMERICANUM*) BY PARAQUAT DUE TO COPPER FUNGICIDES

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Abstract. **Common nightshade (*Solanum americanum* Mill.) plants were sprayed with paraquat (1, 1-dimethyl-4, 4-bipyredinium) at 0.0, 0.25, or 0.50 lb./acre after being treated with a cupric hydroxide fungicide 3 times per week for 0, 1, or 2 weeks. Abscission of leaves from plants treated with either rate of paraquat was greater when no Cu fungicide was applied. The nightshade showed increased regrowth when the Cu fungicide was applied for two weeks.**

Common nightshade is a serious weed problem in Florida tomato production. It is difficult to control with selective herbicides in crops such as tomato (*Lycopersicon esculentum* Mill.), pepper (*Capsicum annuum,* L.), and eggplant (*Solanum melongena* L.) because of similar physiology and close genetic relationship. Yield losses in tomato have been documented due to increasing interference from nightshade species (5). The use of soil fumigation and polyethylene mulch in vegetable production has eliminated most weeds from the surface of raised beds. Weed control in the row middles is still a significant problem.

Florida Agriculture Experiment Station Journal Series No. 8633.

For several years growers in southwest Florida have reported what they believed to be the development of resistance to paraquat by nightshade. Originally some believed this resistance to be the result of nightshade plants being hardened by cold or other stresses (3). In experiments at the Gulf Coast Research and Education Center, paraquat provided adequate control of young nightshade plants (2). It was observed that nightshade growing in growers' fields was found primarily along the edge of the plastic mulch. In experiments in commercial fields in the Immokalee-Naples area, paraquat was applied to nightshade at increasing rates. Adequate control was not achieved (6). From these results the hypothesis that control loss was due to lack of coverage was discarded.

Paraquat is subject to hydrolysis in the presence of alkaline materials (1, 5). Youngerman et al. (7) found that a novel Cu complex of D-penicillamine significantly inhibited the effects of paraquat on flax (*Linum usestassemum* L.) cotyledons. This Cu chelate acted much like Cu-Zn and Mn containing superoxide dismutase enzymes. The herbicidal activity of paraquat is dependent upon the production of singlet oxygen and hydroxide free radicals. These free radicals cause peroxide formation in the cells, which in turn causes lipid peroxidation and disruption of the tonoplast and plasmalemma. Youngerman proposed that the Cu chelate reacts with the oxygen free radicals, accepting an electron, and prevents lipid peroxidation from beginning.

The use of Cu containing fungicides (cupric hydroxides and cupric sulfate pentahydrates) for control of bacterial diseases is standard in Florida. Nozzle arrangements on sprayers for this application would also apply these chemicals to weeds, nightshade in particular, growing on the margins of the beds.

The objective of this research was to determine whether Cu fungicides applied to nightshade would reduce efficacy of paraquat.

Materials and Methods

Mature berries of common nightshade were harvested from plants in old tomato fields in Collier county midwinter 1986 and spring 1987. Seeds were extracted by crushing, fermentation, washing and drying. Plants from both collections were identified as *Solanum americanum*, by the IFAS Plant Identification Clinic (D. Hall, personal communication).

Seeds from each collection were planted in a peat-lite mix. Germination time ranged from 28 to 42 days. Young seedlings of approximately the same age were transplanted into 6 inch plastic pots.

Treatments were arranged in a randomized complete block with four replications and consisted of number of Cu applications and three paraquat rates. The Cu treatments were 3 sprays of cupric hydroxide (Kocide 101) per week for 0, 1, or 2 weeks. Each application was made at a rate of 2.31 lb./acre of cupric hydroxide or 1.5 lb./acre Cu equivalent. Paraquat (Gramoxone Super) was applied 3 days after the last Cu application at 0.0, 0.25, or 0.50 lb./acre on 8 Apr. 1986. Applications were made with a CO_2 powered backpack sprayer with a single 8004 nozzle at a delivery rate of 30 gal/acre. One week after the paraquat application the number of leaves remaining on the plants was recorded. The plants were also evaluated for regrowth. The experiment was repeated using younger plants with paraquat application on 3 June 1986.

Results and Discussion

There was no visible difference in the growth or color of the nightshade plants due to the number of Cu sprays. All plants were vigorous and healthy. In the first experiment, the plants were examined 1 day after paraquat application for symptoms of desiccation of leaves and stems. Where Cu had been applied the plants had small areas of desiccated tissue. The stems and leaves of plants receiving no Cu sprays were completely desiccated. Quantification of this observation by direct measurement or methods such as the Horsfall-Barett scale did not prove either accurate or feasible. By the third day after paraquat application damaged leaves were abscising. At this time areas of the plants were collapsing from herbicide damage to the stem. After one week it was felt that the number of leaves remaining on the plants gave an accurate representation of the control due to the paraquat treatments. Results of the tests are shown in Table 1.

In experiment 1, the mean number of leaves remaining on untreated plants was 1.75, where no Cu fungicide was applied, the mean number of leaves per plant was 3.03 at 0.25 lb./acre paraquat and 1.78 at 0.50 lb./acre paraquat. These were significantly lower than when the same rates were applied to plants treated with Cu fungicides for two weeks. When paraquat was applied at 0.50 lb/acre (labeled rate) to plants treated with Cu for 1 week, the number of leaves per plant was not significantly greater than when no Cu was applied. This treatment provided significantly fewer leaves per plant than when 0.25 lb./acre paraquat was applied to plants treated with Cu for 2 weeks. There were no significant differences between any of the other treatments.

In the second experiment the untreated control provided a mean of 11.75 leaves per plant. All paraquat/Cu treatments significantly reduced the number of leaves per plant. The number of leaves per plants on plants treated with both rates of paraquat with no Cu fungicide was significantly lower than all other Cu treatments. Plants treated with Cu for 2 weeks and sprayed with 0.25 lb./acre paraquat had significantly more leaves than other paraquat/copper combinations. Plants treated 1 week with Cu and either paraquat rate, or 2 weeks with Cu and 0.50 lb./acre paraquat were statistically the same.

Table 1. Effect of copper sprays and paraquat rate on number of leaves remaining on common nightshade plants.

Treatments		No. of leaves/plant	
Copper sprays (weeks)	Paraquat (lb./acre)	Expt. 1	Expt. 2
0	0.0	16.75 a[z]	11.75 a
2	0.25	10.00 b	8.50 b
2	0.50	7.75 bc	6.25 c
1	0.25	6.25 bcd	6.25 c
1	0.50	4.52 cde	5.25 c
0	0.25	3.03 de	1.0 d
0	0.50	1.78 e	0.25 d

[z] Mean separation by Duncan's multiple range test, 1% level.

In both experiments the only treatments which would have been *classified* as commercially acceptable were those where no Cu was applied.

Regrowth of the plants followed a very similar pattern as the leaves per plant data. The stems were killed to the base of the plant when no Cu fungicide was applied. Where paraquat was sprayed any regrowth occurred from the crown. When Cu was applied for 1 week the stem collapsed in the upper portion of the plant and regrowth was from axillary buds on the stem. Regrowth from plants treated for 2 weeks with Cu fungicides was primarily new leaf formation from the established stems.

Results of these experiments demonstrate that there is an antagonism between cupric hydroxide fungicides and paraquat on common nightshade. This antagonism is a major factor in the loss of control of this plant by paraquat. Further studies will explore additional Cu fungicide inhibition and methods for overcoming the Cu-paraquat interactions.

Selected References

1. Beste, E. E. 1983. Herbicide Handbook of the Weed Science Society of America. Fifth Ed. 362-366.
2. Gilreath, J. P. 1987. Control of nightshade and other weeds in row middles of mulched tomato. Bradenton GCREC Research Report BRA 1987-11.
3. Gilreath, J. P. and W. M. Stall. 1987. Control of nightshade and other weeds in tomato row middles. Fla. Tomato Inst. VEC 87-3:28-33.
4. Hatzros, K. K. and D. Penner. 1985. Interactions of herbicides with other agrochemical in higher plants. Rev. Weed Sci. 1:1-73.
5. Weaver, S. E., N. Smits, and C. S. Tan. 1987. Estimating yield losses of tomatoes (*Lycopersicon esculentum*) caused by nightshade (*Solanum* spp.) in reference. Weed Sci. 35:163-168.
6. Younce, H. D. 1986. ICI Research Report. 218A.
7. Youngerman, R. J., A. D. Dodge, E. Lengelder, and E. F. Elstner. 1979. Inhibition of paraquat phytotoxicity by a novel copper chelate with superoxide dismutating activity. Experentia 35:1295-1296.

Proc. Fla. State Hort. Soc. 100:224-226. 1987.

WEED CONTROL AND TOLERANCES OF CHINESE CABBAGE AND CHINESE BROCCOLI TO PRE AND POSTEMERGENCE HERBICIDES ON MINERAL SOILS

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Additional index words. Bok Choy, Napa, *Brassica rapa*, *B. oleracea* var. *alboglabra*.

Abstract. **Preemergence and pre- and posttransplant applications of various herbicides were made to bok choy (*Brassica rapa* L. Chinesis Group), napa (*Brassica rapa* L. Pekinensis Group), and Chinese broccoli (*Brassica oleracea* var. *alboglabra* Bailey) to evaluate crop tolerance and weed control. The three crops were direct seeded at Boynton Beach and bok choy was transplanted at Gainesville. Crop vigor 20 days after planting was acceptable with diethatyl (2.0 lb./acre), thiobencarb (6.0 lb./acre), napropamide (2.0 lb./acre), and metolachlor (1.5 lb./acre). Vigor was reduced with oxyfluorfen (0.125 and 0.25 lb./acre) and cinmethylin (0.75 lb./acre). Vigor of bok choy 31 days after transplanting was acceptable with posttransplant applications of diethatyl, thiobencarb (8.0 lb./acre), napropamide, metolachlor, and cinmethylin (0.5 lb./acre). Vigor was reduced with pretransplant applications of metolachlor and oxyfluorfen (0.5 lb./acre) and the posttransplant application of thiobencarb (16.0 lb./acre). All herbicides provided acceptable early grass control. Early broadleaf weed control was acceptable with all treatments except with preemergence applications of napropamide and cinmethylin. Chinese broccoli and napa yields were reduced by the preemergence application of cinmethylin. Bok choy yields were reduced at the higher rates of oxyfluorfen and thiobencarb.**

Over 5,000 acres of Chinese vegetables were harvested in Florida in the 1986-87 season. Gross sales were estimated at $9 million. Over 4,000 acres were grown on sand and muck soils in Palm Beach County (1). Additional sandland production was located in Hillsborough and Orange Counties and additional production on muck soils was located in Brevard County (R. L. Mitchell, T. Staley, and C. Schoenfeld, personal communications).

Trifluralin, DCPA, napropamide, and oxyfluorfen are currently labelled for use on cabbage and broccoli. The residue tolerances for cabbage and broccoli apply to napa (tight-headed Chinese cabbage) and Chinese broccoli (Dr. C. W. Meister, IR-4 Southern Region Coordinator, personal communication). However, there are currently no herbicide labels for these crops. Approximately 1,500 acres of napa and Chinese broccoli are grown in Florida. Loose and semi-loose headed types of Chinese cabbage, which include bok choy, chihili, choy-sum and yu-choy are grown on approximately 3,000 acres. There are no tolerances for herbicides on these crops.

In South Florida, Chinese cabbage and Chinese broccoli are typically direct seeded on open beds. Growers cultivate 2 to 3 times with rolling cultivators beginning 10 to 14 days after seeding. Cultivation is discontinued 4 to 5 weeks after planting to avoid crop injury. For napa and bok choy, weeds are pulled by hand at thinning. For Chinese broccoli and yu-choy, weeds are pulled by hand without thinning. The cost of the thinning and weeding is $125-150 per acre (T. Yee, Yee Farms, personal communication).

Pretransplant applications of oxyfluorfen and posttransplant applications of metolachlor, diethaltyl, and nap-

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Florida Agricultural Experiment Stations Journal Series No. 8755.