Suppression of Oxidant Injury on Beans by Systemic Fungicides

W. J. Manning and P. M. Vardaro

Assistant Professor and Technician, respectively, Suburban Experiment Station, University of Massachusetts, Waltham 02154.

Accepted for publication 15 May 1973.

ABSTRACT

The effectiveness of the systemic fungicides benomyl, carboxin, and triarimol, in suppressing oxidant injury on bean cultivars 'Tempo' and 'Pinto III', was determined under field conditions. Benomyl sprays, at 2.4 and 3.6 g/liter once a week for 4 weeks, provided 70-80% suppression of oxidant injury. Plants sprayed with carboxin and triarimol, or from seed treated with carboxin, showed as much oxidant injury as untreated control plants. Carboxin, in a 10% granular form, at 7.9 g/4.6 m row over seed at planting, provided complete suppression of visible oxidant injury that lasted for 36-40 days.

Phytopathology 63:1415-1416

Many chemical compounds have been shown to be effective in suppressing smog or oxidant air pollution injury on plants (1, 3, 9, 11, 12, 16). Most have not been put to practical use. The fungicides benomyl (Benlate), carboxin (Vitavax), and triarimol (EL273) have been reported to be effective in suppressing oxidant or ozone injury and, because of systemic activity, may have practical applications (7, 8, 10, 11, 12, 13, 14). Benomyl sprays (10, 12) and soil applications of benomyl and carboxin (14), were effective in suppressing oxidant fleck on tobacco. Information is not available on the effectiveness of these two fungicides or triarimol in suppressing oxidant injury on other plants under field conditions. We evaluated these three fungicides for effectiveness in suppressing oxidant injury on beans in the field. A brief account of our results has been published previously (7).

MATERIALS AND METHODS.—Bean (*Phaseolus vulgaris* L.) cultivars Tempo and Pinto III were grown in 4.6 m rows in a field of Merrimac fine sandy loam. Each row contained 20 plants. Four replications were used. Each replication contained two rows of each bean cultivar. One row of each cultivar was treated and the other was not treated. Test 1 was conducted from 12 June to 10 July, and test 2 from 17 July to 14 August 1972. Both bean cultivars are sensitive to ozone and oxidant injury at low levels (4, 5, 6).

Benomyl at 0.6, 1.2, 2.4, and 3.6 g/liter; carboxin, at 8 and 24 μg/ml; and triarimol, at 50, 75, and 100 μg/ml were applied once a week for 4 weeks as foliar sprays, beginning 5 days after seedling emergence. Carboxin, in a 75% W P form, was used as a seed treatment at 1.25, 2.50, 3.75, and 5.00 g/kg seed. Carboxin, in a 10% granular form, was applied in rows over seed at planting at 2.7, 5.3, and 7.9 g/4.6 m row. Plants were observed daily for incidence of oxidant injury. Final evaluations were made 5 weeks after seedling emergence, and consisted of estimations of differences in percent suppression of visible oxidant injury between treatments and controls.

Oxidant data (mostly ozone measurements) was obtained by using continuously operating Mast meters equipped with a sulfur dioxide scrubber. Meters were calibrated every 3 weeks. Background levels of sulfur dioxide were measured on a Davis Conductivity Instrument and seldom reached recordable levels.

Oxidant levels exceeded 4 pphm frequently in the June through August period. Eighty-nine hours above 4 pphm were recorded in June, 142 in July, and 96 in August for a total of 227 hours. This threshold level was used because Tempo is sensitive to ozone at 4 pphm and below (Manning and Vardaro, *unpublished*).

RESULTS.—Leaves of untreated control plants of both bean cultivars exhibited chlorotic leaf mottling, red-brown pigmentation, bronzing, and yellowing. This was followed by premature senescence. Occasional necrotic flecks were observed. These symptoms correspond to previous descriptions of low-level ozone or chronic oxidant injury on beans (2, 3, 4, 6, 17). Symptom expression was similar on leaves of both bean cultivars. The intensity of

TABLE 1. Suppression of oxidant injury on field-grown 'Pinto' and 'Tempo' bean plants by systemic fungicides

Treatments	Estimated percent suppression of oxidant injury[c]			
	Test 1		Test 2	
	Pinto	Tempo	Pinto	Tempo
Foliar sprays[a]				
Benomyl				
0.6 *or* 1.2 g/liter	0	0	0	0
2.4 *or* 3.6 g/liter	80	75	70	75
Carboxin				
8 *or* 24 μg/ml	0	0	0	0
Triarimol				
50, 75, *or* 100 μg/ml	0	0	0	0
Soil treatments[b]				
Carboxin (10% granular)				
2.7 *or* 5.3 g/ 4.6 m row	0	0	0	0
7.9 g/ 4.6 m row	100	100	100	100
Seed treatments				
Carboxin (75% W.P)				
1.25, 2.50, 3.75 *or* 5.00 g/kg bean seed	0	0	0	0

[a] Applied once a week for 4 weeks.
[b] Granules applied over seed in furrow at planting.
[c] Comparison of treated plants with nontreated controls.

symptom expression appeared to be somewhat greater on leaves of Tempo. Benomyl sprays at 2.4 or 3.6 g/liter once a week, provided 70-80% suppression of chronic oxidant injury on treated plants of both bean cultivars when compared to untreated control plants (Table 1). This is similar to results with field-grown tobacco (10, 13), and differs from results obtained from laboratory experiments on suppression of injury on Pinto bean caused by a high ozone level (25 pphm) (8). Benzimidazole (active component of benomyl) also inhibited senescence in Pinto beans (15). Leaves sprayed with triarimol showed as much injury as untreated controls, and those treated at the 75 and 100 μg/ml levels exhibited cupping, dwarfing, and greening. Triarimol has been reported to suppress acute ozone injury on Pinto beans under laboratory conditions (11, 12). The adverse effects of triarimol on bean leaves and internodes, have also been previously noted (12). Plants sprayed with carboxin, or from seed treated with carboxin, exhibited as much oxidant injury as untreated control plants. Carboxin, in a 10% granular form, at the rate of 7.9 g/4.6 m of row, provided complete suppression of oxidant injury on both bean cultivars. This effect lasted 36-40 days; however, it broke down at flowering and pod set. All carboxin soil and seed treatments resulted in yellowing and burning of the margins of primary leaves. Similar phytotoxicity has been observed with tobacco grown in carboxin-treated soil (14).

CONCLUSIONS.—Benomyl foliar sprays at 2.4 or 3.6 g/liter suppressed 70-80% of the oxidant injury on both bean cultivars. Frequent applications and high rates, however, were necessary to achieve these effects. A single application of carboxin, in a 10% granular form, over seed at planting, completely suppressed visible oxidant injury on beans in the field for 36-40 days. Based on this, future work with carboxin as a suppressant of oxidant injury on field-grown plants appears warranted.

LITERATURE CITED

1. DAAS, H. C., & G. M. WEAVER. 1968. Modification of ozone damage to Phaseolus vulgaris by antioxidants, thiols, and sulfhydryl reagents. Can. J. Plant Sci. 48:569-574.
2. HAAS, J. H. 1970. Relation of crop maturity and physiology to air pollution incited bronzing of Phaseolus vulgaris. Phytopathology 60:407-410.
3. HEGGESTAD, H. E., & W. W. HECK. 1971. Nature, extent, and variation of plant response to air pollutants. Adv. Agron 23:111-145.
4. HOWELL, R. K. 1970. Influence of air pollution on quantities of caffeic acid isolated from leaves of Phaseolus vulgaris. Phytopathology 60:1626-1629.
5. HOWELL, R. K. 1970. Differential responses of bean cultivars to ozone and ambient air. Hort. Sci. 5:334 (Abstr.).
6. MANNING, W. J., W. A. FEDER, & P. M. PAPIA. 1972. Influence of long-term low levels of ozone and benomyl on growth and nodulation of Pinto bean plants. Phytopathology 62:497 (Abstr.).
7. MANNING, W. J., & P. M. VARDARO. 1973. Suppression of oxidant air pollution injury on bean plants by systemic fungicides under field conditions. Phytopathology 63: 204 (Abstr.).
8. PELLISSIER, M., N. L. LACASSE, & H. COLE, JR. 1972. Effectiveness of benomyl and benomyl-folicote treatments in reducing ozone injury to Pinto beans. J. Air Pollut. Control Assoc. 22:722-725.
9. PELLISSIER, M., N. L. LACASSE, C. D. ERCEGOVICH, & H. COLE, JR. 1972. Effects of hydrocarbon wax emulsion sprays in reducing visible ozone injury to Phaseolus vulgaris Pinto III. Plant Dis. Reptr. 56:6-9.
10. REINERT, R. A., & H. W. SPURR, JR. 1972. Differential effect of fungicides on ozone injury and brown spot disease of tobacco. J. Environ. Qual. 1:450-452.
11. SEEM, R. C. 1972. Evaluation of potential chemical protectants from ozone damage to Phaseolus vulgaris L. Penn. State Univ. Center for Air Environ. Studies Publ. No. 291-92. 60 p.
12. SEEM, R. C., H. COLE, JR., & N. L. LACASSE. 1972. Suppression of ozone injury to Phaseolus vulgaris Pinto III with triarimol and its monochlorophenyl cyclohexyl analogue. Plant Dis. Reptr. 56:386-390.
13. TAYLOR, G. S. 1970. Tobacco protected against fleck by benomyl and other fungicides. Phytopathology 60:578 (Abstr.).
14. TAYLOR, G. S., & S. RICH. 1973. Ozone fleck on tobacco reduced by benomyl and carboxin in soil. Phytopathology 63:208 (Abstr.).
15. TOMLINSON, H., & S. RICH. 1973. Relating ozone resistance to antisenescence in beans treated with benzimidazole. Phytopathology 63:208 (Abstr.).
16. WALKER, E. K. 1967. Evaluation of foliar sprays for control of weather fleck of flue-cured tobacco. Can. J. Plant Sci. 47:99-108.
17. WEAVER, G. M., & H. O. JACKSON. 1968. Relationship between bronzing in white beans and phytotoxic levels of atmospheric ozone in Ontario. Can. J. Plant Sci. 48:561-568.