

CGA-48988, A NEW SYSTEMIC FUNGICIDE FOR CONTROL OF PHYTOPHTHORA NICOTIANAE VAR. PARASITICA ON PEPEROMIA OBTUSIFOLIA¹

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Abstract. A new experimental soil fungicide, CGA-48988, was found to be active at very low concns in control of *Phytophthora nicotianae* var. *parasitica*. Suspensions of wettable powder applied as soil drenches and granular formulations incorporated into the potting mix or applied to the soil surface proved effective in control of the pathogen on *Peperomia obtusifolia* (L.) A. Dietr. Drench concns as low as 6 ppm (6 mg a.i./liter) at 1 pt/ft² (509 ml/1000 cm²) of soil surface and soil incorporation of a 5% granular (5G) formulation at 3.5 oz/yd³ (0.13 kg/m³) provided complete control. Applications of a 1% granular (1G) formulation to the soil surface resulting in a final concn equal to a 2 ppm (2 mg a.i./liter) drench at 1 pt/ft² also provided control. One drench of CGA 48988 to rooted cuttings provided control when pots were infested 56 days after the initial drench. All formulations of the compound at all concns tested proved non-phytotoxic. CGA-48988, soluble in water, possibly was adsorbed by organic matter in the soil medium and later released and/or absorbed initially by roots, stored, and later redistributed into newly-produced, root tissue. Results indicate the compound to have chemotherapeutic activity.

The crown and leaf rot of *Peperomia obtusifolia* (L.) A. Dietr. caused by *Phytophthora nicotianae* var. *parasitica* (Dast.) Waterh. (1, 4, 5) is a common and difficult disease to control in the Florida foliage plant industry. Present cultural and sanitation procedures do not allow Florida foliage growers assurance of complete freedom from this pathogen. Many commercially available disease control fungicides have been tested under experimental and industry conditions for their effectiveness in control of this pathogen with few exhibiting any degree of success. Ethazole and Dexon, 2 commercially available soil fungicides listed as active against *Phytophthora* spp., at best, provide moderate to fair control of *Phytophthora* crown rot of *peperomia*.

Recently, CGA 48988 (metaxanin), a new experimental acylalanine fungicide (Ciba-Geigy Corp., Greensboro, NC) has shown excellent promise in control of pythiaceus pathogens. The work reported here was undertaken to evaluate CGA 48988 for potential phytotoxicity and efficacy in control of *P. nicotianae* var. *parasitica* on *P. obtusifolia*.

Materials and Methods

The common green *P. obtusifolia* was employed in all tests. Cuttings in all tests were cut to uniform size and rooted directly (except in Test 2) in the pot for 3 weeks under intermittent mist (15 sec every 30 min) applied from 8 a.m. to 7 p.m. In Test 2 the cuttings were rooted in flats containing steam-pasteurized peat moss prior to potting. The soil mix was steam-pasteurized and consisted of 2 parts

German peat and 1 part coarse builder's sand plus 7 lb (3.2 kg) dolomite and 2 lb (0.9 kg) Perk (minor elements supplement Kerr-Magee Chemical Co., Jacksonville, FL)/yd³ (0.76 m³). The number of pots contained in each treatment were 8, 10, 10, 5, and 5 in Tests 1, 2, 3, 4, and 5, respectively.

The fungicides tested as drenches, soil incorporation or surface application were: Benlate 50 WP (benomyl); the experimental compound CGA-48988, formulation 50 WP, 25 WP, 5 G and 1 G; Nurelle 7.2 EC (pyroxychlor); and Truban 30 WP (ethazole). Benlate, although inactive against pythiaceus fungi, was included to determine whether it would affect the severity of disease development caused by pythiaceus pathogens similar to those noted previously (2, 3, 6). The drenches were applied 2 days after the infestation except in Tests 4 and 5 where drenches were delayed to determine the therapeutic potential of CGA-48988. In Test 3, pots were drenched and infested up to 56 days later to determine residual activity of the experimental compound. The granular forms of CGA-48988 were tested by soil incorporation in Test 2 and by application to the soil surface in Tests 4 and 5. Immediately after surface application, water at 1 pt/ft² was applied to the treated and control pots. The pots utilized in all tests except Test 2 were new 4-inch (10.2 cm) square plastic pots. Pots in Test 2 were 5-inch (12.7 cm) round plastic. Treatments were arranged in a randomized block design with all pots placed onto sterilized wooden blocks on raised benches in a glass greenhouse with temp ranging from 65-95 F (18-35 C). Plants were watered 2 times/week during the first month and then 3 times/week thereafter until termination of the test. Fertilization was included in the watering by adding soluble 20-20-20, 1 lb/100 gal (119.8 g/liter) once every other week in the former and once a week in the latter watering regime.

The isolate of *P. nicotianae* var. *parasitica* was the same as that employed in previous tests (4). It was originally isolated from a diseased *P. obtusifolia* stem and maintained by periodic transfer on lima bean agar. Inoculum consisted of a thoroughly chopped and mixed 2-week-old oatmeal sand culture [1.4 oz (39.7 g) Quaker Oats + 7.0 oz (198.4 g) washed coarse builder's sand + 3-3.4 fl oz (90-100 ml) deionized water, autoclaved twice on successive days at 250 F (121 C) for 60 min] and grown at 77-80 F (25-27 C). Each pot received 0.30 in³ (5 cm³) of inoculum placed in a hole made in the soil surface in the center of the pot. Non-infested control pots were handled similarly but received sterile oatmeal sand.

Data were taken on disease severity, fresh wt of top, and no. of plants remaining during and/or at the conclusion of the tests. Disease severity ratings were based on the following scale: 1 = no disease, 2 = slight stem discoloration, 3 = definite blackening of the stem, and 4 = severe blackening and collapse of the stem. In some tests, differences between treatment means were evaluated by analysis of variance with significant means separated by Duncan's multiple range test.

Results and Discussion

The experimental compound CGA 48988 provided excellent control of *P. nicotianae* var. *parasitica*. The compound in the WP form was effective as a drench and effective in the granular form when incorporated into or broadcast over growing media. It provided control superior to that achieved with either Truban or Nurelle, the latter

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compound having been shown previously (4) to possess outstanding efficacy against this pathogen on peperomia. In both Tests 1 and 2 (Tables 1 and 2), the inclusion of Benlate with Nurelle increased disease development, an effect noted previously (2, 3, 6) when benzimidazole-type compounds were applied alone or in combination with other fungicides to soils containing pythiaceus pathogens. It is important to be aware that this apparent increase in disease severity of pythiaceus fungal diseases may occur when Benlate or other benzimidazole-type compounds are included in fungicide drench combinations used to obtain broad spectrum control. It should also be noted, that the Nurelle + Benlate combination treatment produced no phytotoxic effects upon peperomia in the non-infested (NI) companion phytotoxicity study (Table 1) so that the effect appears not to be the result of increased susceptibility resulting from injury to plant tissue.

CGA 48988 proved to have excellent residual activity and chemotherapeutic potential on infected plants. Peperomia plants drenched with the compound up to 56 days prior to soil infestation appeared to contain adequate concns of

Table 1. The efficacy and potential phytotoxicity of several commercial and experimental soil fungicides and fungicide combinations in control of *Phytophthora* crown rot of peperomia (Test 1, 2/31/76 to 6/21/76).

Treatment	Concn/100 gal	Disease severity ^x (I)	Top wt % control (NI)
Control - I ^a	—	3.7	—
Control - NI ^a	—	1.0	100
Nurelle + Benlate ^a	150 ppm + 8 oz	2.1	104
Nurelle + Benlate ^b	150 ppm + 8 oz	3.1	105
Truban WP ^a	12 oz	3.8	96
Truban WP ^b	12 oz	3.4	96
Nurelle ^a	150 ppm	1.6	85
Nurelle ^b	150 ppm	1.8	95
CGA 48988 25 WP ^a	25 ppm	1.0	109
CGA 48988 25 WP ^b	25 ppm	1.0	106
CGA 48988 25 WP ^c	12.5 ppm	1.0	103

^aDrench at 2 pt/ft².

^bDrench at 1 pt/ft².

^cDisease severity: 1 = no disease, 2 = slight stem discoloration, 3 = definite stem blackening, and 4 = severe stem blackening and stem collapse. I = infested treatment, data taken 101 days after infestation; NI = non-infested, data for phytotoxicity taken 56 days after infestation.

Table 2. The efficacy and potential phytotoxicity of CGA 48988 25WP drenches and 5G soil-incorporated in comparison to other soil fungicides in control of *Phytophthora* crown rot of peperomia (Test 2, 4/27/76 to 8/17/76).

Treatment	Drench Concn/100 gal	Soil incorp. oz/yd ³	Total top wt ^y (oz)		Disease severity ^y		No. plants remaining ^y	
			I	NI	I	NI	I	NI
CGA	62.5 ppm	—	31.5	18.4	1.0	1.0	20	20
CGA	25 ppm	—	33.1	18.8	1.0	1.0	20	20
CGA	6.2 ppm	—	30.0	20.0	1.3	1.0	20	20
CGA	1.2 ppm	—	0.0	20.4	4.0	1.0	0	20
Nurelle ^a	150 ppm	—	16.0	18.6	2.2	1.0	12	20
Nurelle + Benlate	150 ppm + 8 oz	—	8.9	17.7	3.0	1.0	7	20
Nurelle	150 ppm	—	25.5	19.1	1.3	1.0	18	20
Truban WP	12 oz	—	0.0	21.2	4.0	1.0	0	20
CGA	—	3.5	33.3	18.7	1.0	1.0	20	20
CGA	—	7.0	29.0	19.2	1.0	1.0	20	20
CGA	—	10.5	30.8	21.1	1.0	1.0	20	20
CGA	—	14.0	33.8	20.0	1.0	1.0	20	20
CGA	—	17.5	30.0	20.9	1.0	1.0	20	20
Control	—	—	0.0	21.5	4.0	1.0	0	20

^aDrenched at 2 pt/ft², all others receiving drenches treated at 1 pt/ft².

^yData taken on non-infested (NI) treatments 14 days prior to infested (I) treatments and 57 days after infestation. Disease severity scale: 1 = no disease, 2 = slight stem discoloration, 3 = definite stem blackening, and 4 = severe stem blackening and stem collapse.

CGA 48988 to provide protection while all infested controls became severely diseased (Table 3). It will be noted that the infested controls exhibited increasing disease development with later dates of infestation. This was most probably due to the increase in temp as the test progressed into the summer months. Chemotherapeutic activity is demonstrated in Tables 4 and 5. The more rapid disease development in Test 4 (Table 4) is accounted for by the fact it was performed during the summer of 1977 as opposed to Test 5 (Table 5) which was carried out during the cold late winter and early spring months of 1976-77. Of particular note is the fact that in Test 4 (Table 4), 10 plants total within the 7 day treatments were showing symptoms of moderate to severe disease severity at the time of fungicide application and that disease development within these treatments practically ceased after CGA 48988 application. It appears that as long as roots are present to take up the compound there is a good possibility for uptake and chemotherapeutic activity.

Table 3. Residual activity of CGA 48988 50 WP drenches applied 14, 28, 42 and 56 days before infestation of peperomia media with *Phytophthora nicotiana* var. *parasitica* (Test 3, 3/29/77 to 7/15/77).

Treatment	Days infested after CGA 48988 treatment	Disease severity ^{y, x} (days after CGA 48988 application)	
		66 (6/24/77)	87 (7/15/77)
CGA ^a	14	1.0	1.0 a
Control - I	14	1.7	2.5 b
Control - NI	14	1.0	1.0 a
CGA ^a	28	1.0	1.0 a
Control - I	28	1.4	3.3 c
Control - NI	28	1.0	1.0 a
CGA ^a	42	1.0	1.0 a
Control - I	42	2.3	3.7 c
Control - NI	42	1.0	1.0 a
CGA ^a	56	1.0	1.0 a
Control - I	56	1.0	3.9 c
Control - NI	56	1.0	1.0 a

^aDrenched on 4/19/77 with 6.2 ppm suspension at volume of 1 pt/ft². Control pots received identical amount water. Separate control groups for each infestation date.

^yTen 5-inch round pots/treatment, 2 plants/pot. Disease severity scale: 1 = no disease, 2 = slight stem discoloration, 3 = definite stem blackening, and 4 = severe stem blackening and stem collapse.

^xMeans within a column not followed by the same letter are significantly different (P = 0.05). Duncan's multiple range test.

Table 4. Chemotherapeutic potential of CGA 48988, 50WP applied as a drench and a 1G broadcast to the soil surface followed by a water drench for control of *Phytophthora* crown rot of *peperomia* (Test 4, 7/12/77 to 8/29/77).

Treatment	Drench concn/100 gal	Broadcast oz/1000 ft ²	Days applied after infestation	Disease severity ^w		
				10 days	20 days	27 days
CGA ^a	6.2 ppm	—	4	1.0	1.0	1.0
CGA ^b	—	41.2	4	1.0	1.0	1.0
CGA ^{a, x}	6.2 ppm	—	7	2.8	3.0	3.1
CGA ^{b, x}	—	41.2	7	2.2	2.2	2.2
Control — I	—	—	—	1.0	1.0	1.0
Control — NI	—	—	—	2.9	4.0	4.0

^aDrench applied at volume equal to 1 pt/ft² of soil surface.

^bApplied broadcast to soil surface and followed with water drench at 1 pt/ft². Final active concn in pot equal to 25 ppm suspension applied at 1 pt/ft².

^xAt time of CGA 48988 application, 6 and 4 plants in the drench and granular broadcast treatments showing moderate to severe stem rot, respectively.

^wData refers to days after infestation. Disease severity scale: 1 = no disease, 2 = slight stem discoloration, 3 = definite stem blackening, and 4 = severe stem blackening and stem collapse.

Table 5. Chemotherapeutic potential of CGA 48988, 50WP applied as a drench and 1G broadcast to the soil surface followed by a water drench for the control of *Phytophthora* crown rot of *peperomia* (Test 5, 12/14/76 to 3/22/77).

Treatment	Drench Conc/100 gal	Broadcast oz/1000 ft ²	Days applied after infestation	No. plants ^w remaining	Disease ^{w, u} severity	Total top ^{w, u} wt. (oz)
CGA ^a	6.2 ppm	—	2	10	1.0 a	12.7 bcd
CGA ^b	—	3.2 ^x	2	10	1.0 a	11.5 bcd
CGA ^a	6.2 ppm	—	4	10	1.0 a	12.3 bcd
CGA ^b	—	3.2 ^x	4	10	1.0 a	11.0 bcd
CGA ^a	6.2 ppm	—	7	10	1.0 a	13.6 bcd
CGA ^b	—	3.2 ^x	7	8	1.6 a	8.3 bc
CGA ^a	6.2 ppm	—	14	10	1.0 a	10.0 bc
CGA ^b	—	3.2 ^x	14	9	1.3 a	8.9 b
Control — NI	—	—	—	10	1.0 a	10.3 bc
Control — I	—	—	—	0	4.0 b	0.0 a

^aApplied at volume of 1 pt/ft² of surface area.

^bWater drench applied at volume of 1 pt/ft² after broadcast.

^xApplication concn equivalent to drench of 2 ppm solution applied at 1 pt/ft².

^wData taken 79 days after infestation. Disease severity scale: 1 = no disease, 2 = slight stem discoloration, 3 = definite stem blackening, and 4 = severe stem blackening and stem collapse.

^uMeans within a column not followed by the same letter are significantly different (P = 0.05). Duncan's multiple range test.

CGA 48988 is unquestionably a compound that provides excellent control of *P. nicotianae* var. *parasitica* on *peperomia*. In other tests performed at this research center over the past 2 years with this compound, it has also proven equally effective on pythiaceous pathogens of Christmas cactus, pothos, and schefflera. The compound in the granular form also appears to be heat-stable and has proved effective after steam pasteurization in soil at 180 F (82 C) for 30 min (unpublished data). The compound in all forms and methods of application in this research proved non-phytoxic even at concns well above the following suggested use concns levels.

1. Drench, WP formulation, 5-25 ppm (5-25 mg a.i./liter) at 1 pt/ft² (509 ml/1000 cm²).
2. Soil incorporation, 1 G formulation, 5-10 oz/yd³ (0.185-0.37 kg/m³).
3. Surface broadcast, 1 G formulation, 8-40 oz/1000 ft² (0.244-1.21 kg/100 m²).

CGA-48988, reported by the manufacturer to be very soluble in water and easily leached from sandy soils, possi-

bly was adsorbed to the organic portion of the soils employed here and later released and/or absorbed initially by the roots, stored, and redistributed to newly-produced, root tissue to provide continuing protection.

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