

perial,' 'Mikkel White Rochford,' 'Mikkel Dawn Rochford,' and 'Wonder Star.' Acephate and methomyl (Lannate^(R), Nudrin^(R)) were each applied to 3 plants of each cultivar arranged across beds constructed as in Test 2. Applications were made weekly from Sept. 14 to Dec. 16. The plants were then moved to a greenhouse, sprayed Dec. 23 and 29 and evaluated for phytotoxicity on Jan. 6, 1977. This allowed an evaluation of possible phytotoxic responses under higher temperatures and relative humidity.

Results and Discussion

In Test 1, all insecticides significantly reduced the number of *E. ello* larvae on all sample dates (Table 1). Methomyl, endosulfan, and acephate gave 100% control after 1 application while 3 sprays were necessary to achieve this level of control with *Bacillus thuringiensis* var. *kurstaki* Berliner (Dipel WP^(R)). No injury to either foliage or bracts of the 3 cultivars was observed after 8 insecticide applications.

Table 1. Control of *Erinnyis ello* (L.) larvae on poinsettia plants sprayed with insecticides.

Treatment	Lb a.i./100 gal	Avg. no. larvae/15 plants*			
		Nov. 10	Nov. 17	Nov. 26	Dec. 1
Acephate 75SP	0.50	0.0a ^z	0.0a	0.0a	0.0a
Endosulfan 50WP	1.00	0.0a	0.0a	0.0a	0.0a
Methomyl 90SP	0.25	0.0a	0.0a	0.0a	0.0a
Dipel WP ^x	0.50	1.3b	0.7b	0.0a	0.0a
Check	—	2.0c	1.3c	1.0b	1.0b

*Treatments applied Nov. 7, 14, 21, 28; Dec. 5, 12, 19, 1975; Jan. 2, 1976.

^zMeans within a column followed by the same letter not significantly different at the 0.05 level, Duncan's multiple range test.

^xCommercial preparation of *Bacillus thuringiensis* var. *kurstaki* Berliner.

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ACYLALANINES: A NEW CLASS OF SYSTEMIC FUNGICIDES

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Abstract. CIBA-GEIGY experimental fungicides CGA-38140 and CGA-48988 represent a new type of systemic fungicide which has activity against the soil-borne species of *Pythium* and *Phytophthora* and foliar diseases caused by the downy mildew fungi. Greenhouse and field data have shown the high degree of residual and systemic activity of these compounds at low rates of application. Technical and performance data on these 2 compounds are presented and discussed.

The chemical control of plant diseases caused by certain fungi in the class Oomycetes has been based to date on the concept of preventive treatments with all their well known limitations. Therefore, the search for chemicals with systemic and curative properties has been a major objective in

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Since few or no *E. ello* larvae were present in Tests 2 and 3, no larval counts were made. In Test 2, no chemical injury was observed on either cultivar after 12 applications of *B. thuringiensis*, acephate, azinphosmethyl, carbaryl (Sevin^(R)), endosulfan and methomyl. Diazinon produced moderate bract spotting on 'Annette Hegg Diva' and slight spotting on 'Annette Hegg Supreme.' Trichlorfon (Dylox^(R)), Proxol^(R) caused slight tip and marginal necrosis of bracts of both cultivars.

No injury by acephate or methomyl was observed after 12 applications in Test 3 on any cultivar grown under saran. When the plants were moved to a greenhouse and treated 2 additional times, at least slight tip necrosis of foliage was observed on all cultivars. However, foliage of 'Eckespoint Professor Laurie Pink' and 'Mikkel Triumph' treated with methomyl had moderate tip and marginal necrosis. Bracts of most cultivars were uninjured. However, bracts of 'Eckespoint Professor Laurie Pink' had slight (acephate) or moderate (methomyl) tip and marginal necrosis and those of 'Mikkel Dawn Rochford' (both insecticides), 'Paul Mikkelson' (methomyl) and 'Mikkel Fantastic' (acephate) had slight tip necrosis.

Acephate and methomyl were very effective in controlling *E. ello* larvae on poinsettia and were safe on a large number of cultivars grown outdoors under saran shade cloth. Care should be observed with poinsettias grown in the greenhouse, however. Endosulfan and *B. thuringiensis* were safe on 4 cultivars of poinsettia grown under saran although the latter was not as effective as the former against *E. ello* larvae. Azinphosmethyl and carbaryl did not injure poinsettias under saran whereas diazinon and trichlorfon did.

Literature Cited

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agricultural research. CIBA-GEIGY has discovered a new type of systemic fungicide, derived from the acylalanine group, which meets this objective. These fungicides control the soil-borne diseases caused by *Pythium* spp. and *Phytophthora* spp. as well as the downy mildews and late blight. The purpose of this paper is to present the chemistry of CGA-38140 and CGA-48988. Two subsequent papers will be presented on CGA-48988 on ornamentals, therefore this paper will deal with CGA-38140 on ornamentals. Also, some biological data on CGA-38140 and CGA-48988 on other crops will be presented.

Materials and Methods

Our colleagues at CIBA-GEIGY Limited, Basle, Switzerland, determined the chemical and toxicological properties of CGA-38140 and CGA-48988 (2). All efficacy tests reported here were conducted at CIBA-GEIGY research facilities in Vero Beach and Boynton Beach, Florida.

The control of root rots of carnation caused by *Pythium aphanidermatum* and of pepperomia caused by *Phytophthora parasitica* were tested with CGA-38140 50WP applied as a drench (1 pint/square foot) to potted plants. Inoculum

grown on millet seed was added to the potting mix 24 hr after the plants had been transplanted and 24 hr before the pots were drenched.

The control of *Pythium* blight of annual ryegrass was tested in the field with CGA-38140 50WP, CGA-48988 50WP, and ethazole 35WP. The compounds were applied preemergence using 25 gal of water/1000 square feet.¹ Ethazole was reapplied every seven days, CGA-38140 and CGA-48988 every 14 days. The test area was sprinkler irrigated to provide 0.25 inch water nightly. Twenty days after planting, the treatments were rated for stand quality (on the basis of the percentage of the treated area covered with grass) and foliar blight (based on the number of disease loci in each plot).

CGA-48988 50WP was applied to the foliage of 'Russet Burbank' potato plants on a 14-day spray schedule to control late blight. Mancozeb 80W was applied every 7 days. Border rows were artificially inoculated with *Phytophthora infestans* when weather conditions were favorable for disease development.

Downy mildew control on broccoli 'Waltham 29' was evaluated using CGA-48988 50WP and chlorothalonil 75WP. CGA-48988 was incorporated into the soil prior to transplanting; chlorothalonil was applied as a foliar spray every 14 days. Disease ratings were made 45 days after transplanting.

The control of *Pythium* damping-off of cotton was evaluated in the greenhouse. 'Delta Pine 16' cottonseed treated with CGA-48988 50WP or Terracoat L-21 was planted in flats of *Pythium aphanidermatum* infested soil. Stand counts were made 14 days after planting.

CGA-48988 2EC was evaluated for control of tobacco black shank in a field test. The test fungicide was applied in the transplant water or incorporated into the soil prior to planting. Roots of 'Coker 319' tobacco plants were dipped into a dilute suspension of *Phytophthora parasitica* f. *nicotianae* chlamydozoospores prior to machine transplanting. Ratings were made on the basis of visible symptoms 3 months after transplanting.

Results and Discussion

The chemistry and toxicology of technical CGA-38140 and CGA-48988 are depicted in Table 1 and Fig. 1. This information has been previously reported for CGA-38140 (1). Both substances are only slightly toxic to mammals and fish and, relative to other fungicides, are highly water soluble.

Soil drench applications of CGA-38140 provide excellent protection against root rots caused by *Pythium* spp. and *Phytophthora* spp. for up to 12 weeks in container grown plants. The data shown in Table 2 reflect the excellent activity, at low rates, on ornamentals.

The acylalanines have long residual activity as is demonstrated in control of *Pythium* blight of ryegrass (Table 3). The CIBA-GEIGY fungicides applied at 14-day intervals, performed better than the standard which was reapplied every seven days.

Field studies over the last 3 years have confirmed the excellent performance of acylalanines against the foliar diseases caused by certain Oomycetes. Control of late blight can be obtained with CGA-48988 applied on a 14-day spray schedule (Table 4). The data in Table 5 reflect the systemic property of CGA-48988 and its excellent activity against downy mildew. The acylalanines move systemically in an *acro-petal* direction.

As a cottonseed treatment, CGA-48988 provided good

Table 1. Chemical and toxicological properties of technical material.

	CGA-38140	CGA-48988
Structural Formulate:	See Fig. 1	
Chemical Name:	N-(2,6-Dimethylphenyl)-N-(2-furanylcarbonyl)-D L-alanine methyl ester	N-(2,6-Dimethylphenyl)-N-(methoxyacetyl)-D L-alanine methyl ester
Empirical Formulae:	C ₁₇ H ₁₉ NO ₄	C ₁₅ H ₂₁ NO ₄
Solubility in Water at 20°C:	230 ppm	7100 ppm
Formulations:	WP	WP, G, EC
Acute Oral LD ₅₀ (rat):	940 mg/kg	669 mg/kg
Acute Oral LD ₅₀ (mouse):	603 mg/kg	788 mg/kg
Acute Dermal LD ₅₀ (rat):	>3100 mg/kg	>3100 mg/kg
Primary Skin Irritation (rabbit):	mild	mild
Eye Irritation (rabbit):	minimal	mild
LC ₅₀ to four fish species:	10-50 ppm	>100 ppm

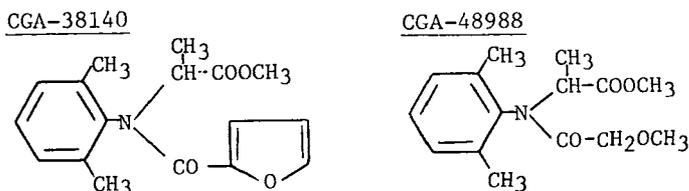


Fig. 1. Structural formulae of 2 acylalanine fungicides.

Table 2. Control of *Pythium aphanidermatum* on Carnations 'Sweet Heart' and *Phytophthora parasitica* on *Peperomia obtusifolia* with CGA-38140 applied as a drench (1 pint/square foot) to potted plants.

Treatment	Rate Oz Active/100 Gal.	No. Healthy plants	
		Carnation	Peperomia
CGA-38140 50WP	0.125	10/10	9/10
CGA-38140 50WP	0.25	8/10	10/10
CGA-38140 50WP	0.50	8/10	10/10
Inoculated Control	—	2/10	1/10
Uninoculated Control	—	10/10	10/10

Table 3. Control of *Pythium* blight on ryegrass with CGA-38140 and CGA-48988.

Treatment	Rate Oz Active/1000 Square Feet	Average Disease
		Index*
CGA-48988 50WP	1.0	4.50
CGA-48988 50WP	2.0	3.75
CGA-38140 50WP	1.0	4.25
CGA-38140 50WP	2.0	3.50
Ethazole 35WP	2.8	7.50
Untreated Control	—	10.00

*Disease evaluation index based on a scale of 0 to 10 with 0 = excellent stand and no disease, 5 = commercially acceptable level of infection, and 10 = plants dead.

¹For metric equivalents see Table near the front of this Volume. Ed.

Table 4. Control of late blight on potatoes 'Russet Burbank' with CGA-48988 applied as a foliar spray.

Treatment	Rate Lb Active/A	Average Disease Index*
CGA-48988 50WP*	0.125	0.38
CGA-48988 50WP*	0.25	0.38
Mancozeb 80WP [†]	1.20	1.13
Control	—	7.50

*Disease evaluation index based on a scale of 0 to 10 with 0 = no diseased plants, 3 = commercially acceptable level of infection, and 10 = plants dead.

*Applied as a foliar spray on 14-day intervals.

[†]Applied as a foliar spray on 7-day intervals.

Table 5. Control of downy mildew on broccoli 'Waltham 29' with CGA-48988 preplant incorporated into the soil.

Treatment	Broadcast Rate (Lb Active/A)	Average Disease Index*
CGA-48988 50WP	0.125	0.00
CGA-48988 50WP	0.250	0.00
CGA-48988 50WP	0.500	0.00
Chlorothalonil 75WP*	1.500	4.00
Control	—	5.75

*Disease evaluation index based on a scale of 0 to 10 with 0 = no diseased plants, 3 = commercially acceptable level of infection, and 10 = plants dead.

*Applied as a foliar spray on 14-day intervals.

control of damping-off caused by *Pythium aphanidermatum*. The greenhouse test results depicted in Table 6 reflect the low rates at which this compound is effective. When used as a seed treatment, CGA-48988 should be mixed with other fungicides since the acylalanines will not control non-pythiaceous fungi.

Control of tobacco black shank has been obtained with both preplant incorporated soil treatments and transplant water treatments of CGA-48988. As shown by the data in Table 7, CGA-48988 2EC applied at 0.5 lb active/A will control black shank.

These data, and a large amount of similar information, demonstrate that the acylalanine fungicides are highly ac-

Table 6. Efficacy of CGA-48988 applied as a seed dressing for the control of *Pythium aphanidermatum* on cotton 'Delta Pine 16' in the greenhouse.

Treatment	Rate oz Active/CWT	Average percent stand
CGA-48988 50WP	0.15	67
CGA-48988 50WP	0.45	57
CGA-48988 50WP	1.20	66
Terracoat L-21	5.62	68
Inoculated Control	—	21
Uninoculated Control	—	90

Table 7. Control of black shank on tobacco 'Coker 319' with CGA-48988.

Treatment	Method of Application	Rate Lb Active/A	Percent of Plants Infected
CGA-48988 2EC	TWT*	0.125	66.7
CGA-48988 2EC	TWT	0.250	18.7
CGA-48988 2EC	TWT	0.500	00.0
CGA-48988 2EC	PPI*	0.500	7.7
CGA-48988 2EC	PPI	1.000	0.0
Control	—	—	97.4

*TWT = transplant water treatment; 225 gallons/A; 6800 plants/A.

*Preplant incorporated in 18-inch band, 12,450 row feet/A.

tive as protective fungicides at rates much lower than the standards. They penetrate plant tissues and exhibit a strong post-infection curative action. And they have a unique combination of residual and systemic activity against the Oomycetes. These qualities, as well as their toxicological and crop safety, make the acylalanines highly useful and flexible disease control agents.

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