FUNGUS CONTROL OF GRAFTED FOLIAGE PLANTS

by

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TABLE OF CONTENTS

INTRODUCTION

In commercial practice, rooted cuttings of foliage plants are wrapped (11) in newspaper to avoid mechanical and freezing injuries (9) and the plants are then packed in corrugated paper boxes and shipped. The packed plant material is stored at room temperatures from 70 to 78 degrees F. Warm temperatures and the naturally fleshy character of these plants provide optimum conditions for fungus disease infection. The fungi attacking foliage plants during transit, are apparently saprophytic or epiphtic in nature, according to Baker and Davis (5), but they frequently cause financial loss to producers by making the plant materials unsalable.

The primary objective of this study was to test the effectiveness of N-Trichloromethylthiotetrahydro Phthalamide (Captan); Methylmercury Dicyandiamide (Panogen), Phenylmercuric Acetate (PMA); Sodium Propionate (PNA), and Copper-8-hydroxiquin (Bioquin); in preventing fungus development on Philodendron oxycardium Schott (6) (P. oxycardium); Scindapsus aureus (Lind. and Andre) Engl. (Ivyarum) (6); Philodendron "hastatum" ("hastatum") (6) and Coleus blumei Benth. (3) (Coleus), under simulated "in transit" conditions.

REVIEW OF LITERATURE

Methods of Controlling Plant Disease

Prevention and Sanitation. Pirone (33) stated that there is rarely a practical cure for plant diseases, and believed that effective control of the great majority of plant diseases rests primarily on the practice of prevention. Post (34) agreed with this statement when he indicated that the program for disease control is therefore based on prevention rather than cure. He stated that diseases of florist crops are likely to be present when cuttings are taken for propagation purposes. He recommended careful selection and treatment of cuttings be followed to avoid inoculating young plants with these organisms.

Baker, et al. (4) strongly emphasized disease prevention by the use of pathogen free propagation material. They illustrate the growers response to this control of disease at source by the selection of chrysanthemum cuttings. In 1943 a method was developed by a A. W. Dimock (10) for selecting chrysanthemum stock plants free of verticillium wilt and this method was adopted by an Ohio propagator. In 1949, nearly 26 1/2 million cuttings were produced in Ohio (49.5 percent of the United States total) largely by this concern.

Miller (28) corroborated the importance of sanitation stating that how a nursery is managed, what the grower does, where and why he does it, must necessarily be influenced by the realization that disease producing organisms are ever present, and that a disease outbreak can make the difference between profit and loss. He further states that as the grower becomes more specialized, the fewer types of plants he grows, the less he can afford to lose from disease, adding that the growing conditions ideal for producing the plants are generally optimum for fungus growth.

According to Laurie (23) one of the common failures of growers is allowing plant material with leaves badly damaged by spots, mildews, etc. to be bunched and packed with clean stock for shipping purposes. Furthermore, Durus (11) pointed out that the proper delivery of nursery stock should be of great concern to the nurseryman; many times plants arrive at their destination in poor condition, due to improper shipping and packing methods.

In this case, Burns strongly advocates the proper wrapping of foliage and roots for foreign shipments.

Post (34) indicated that those organisms that infect many different species of plants and that are spread by air currents, like mildews, Botrytis, Cladosporium, etc. cannot be kept from the growing area. Chemical protectants for these plants or the manipulation of the environment to produce unfavorable conditions for growth of these organisms must be employed.

Modifying the Environment. Reports of investigations related to the control of molds by modifying certain environmental factors, are plentiful in the available literature (12) and (31), but as a general rule, these have been confined to flowers in storage or in transit, and to plants grown in the greenhouse. This is probably due to the fact that in order to modify the environment, an enclosure is generally essential.

Fisher and Keller (12) reported excellent results in preventing mold growth (Botrytis sp.) in carnations and gladiolus under simulated "in transit" conditions using activated brominated charcoal (referred to as B.A.C.) preventing mold invasion. In one of their several trials, carnation flowers previously inoculated with the fungus, were packed in standard florists boxes with B.A.C. suspended by means of wires over the flowers. Carnations were stored in this manner at 50° F. for a period of two weeks and no sign of mold infection could be detected in the flowers. This study revealed the treatment to be less effective when B.A.C. is kept below the flowers, and that B.A.C. can be toxic to the flowers if in direct contact.

An attempt to modify the environment in controlling molds in the greenhouse by using Ozone generators has been made by Miller (29) without much success. He reported that Magie, of the Florida Gulf Coast Experimental

Station is currently studying the control of molds (Botrytis sp.) in gladiolus by treating the plants with Ozone or placing the plants in storage with Ozone generators. These results have not been published, but Miller (29) indicated them to be very promising.

Use of Chemicals. The available literature regarding the use of chemical treatments to control fungi in florists products in abundant, but is generally restricted to the prevention of mold growth in flowers in transit and the storage of flowers and plant material.

Snyder and Hess (39) demonstrated a satisfactory method for handling rooted cuttings of various species of plants by packing the cuttings in polyethylene bags and successfully used Captan to prevent storage molds.

Mahlstede and Kirk (25) used D.H.A.S. ($C_8H_7NaO_4.H_2O$) (referred to as D.H.A.) to prevent mold growth on several species of cuttings while studying the packing of nursery stock for shipment to retail markets.

Runge (36) used Captan to prevent fungi in his studies on storage of various rooted woody cuttings stored at several low temperatures.

Widmoyer (44) studied storage of bare root cuttings of various species using non-perforated polyethylene bags to enclose the cuttings stored at 32° F. - 40° F. He evaluated several fungicides in preventing storage molds. Captan, at .5 percent rate performed very well.

Stessel, as reported by de Ong ([illegible]) studied mold control in dormant rose bushes in cold storage (34° F. - 36° F.) using a 7.5 percent Captan dust to control Botrytis sp. and achieved excellent results when the treatment was preceded by field sprays and good sanitation methods. This control program has wide acceptance today among rose growers.

Captan has been widely used in studying control of storage molds in many horticultural crops, other than florist crops. Harvey (17) used it to reduce decay caused by Botrytis sp. on Emperor grapes in storage. His results were similar to Stessel's when pre-harvest treatments were also given, however, Cladosporium herbarum was not significantly affected by Captan in his field plots.

Seventeen different fungicides were tested and evaluated by Jack and Webb (22) on tomato plants in the greenhouse for the control of Cladosporium fulvum and Captan ranked among the most effective.

Taxonomic Classification of Plants

Birdsey (6) commented on the gap that exists in the available information on the Aroids (Araceae family), indicating that there is a need of herbarium specimens and that those available are often found without the inflorescence, which is necessary for identification even to the genus. He indicated that the poor preparation of herbarium specimens is probably due to the fleshy condition of the plants. Very properly, Birdsey (6) indicated that the many problems in the family require considerably more experimental and field work.

According to Birdsey (6) Philodendron oxycardium Schott, is an Aroid, and this is the correct name for the plant commonly cultivated under the name P. cordatum, adding that both Donn and Aiton gave the date of introduction as 1793 from the West Indies (probably Jamaica).

Scindapsus aureus (Lind. and Andre) Engl., or Ivyarum, also an Aroid, is synonymous to Pothos aureus (Lind. and Andre), according to Birdsey (6). It originated in the Solomon Isles from where it was introduced in the year 1879. For brevity, the common name Ivyarum will be used in this work for Scindapsus aureus.

Philodendron "hastatum", also an Aroid, is of doubtful taxonomic status as stated by Birdsey (6) adding that neither of the two different species sold under this name is Philodendron hastatum Koch and Sellow. The name "hastatum" will be used following Birdsey's (6) suggestion since the plant used in this study corresponds to the one he illustrates on page 83 in his book "The Cultivated Aroids." The plants used had the midrib of the posterior lobe devoid of blade tissue for about 3 centimeters before it joined the petiole. According to Birdsey (6) this vegetative difference indicates that this is one of the species of "hastatum", of doubtful taxonomic status.

The genus Philodendron comprises, according to Graf (14), one of the largest groups of house plants. He presents 182 different types photographed and reproduced in his pictorial Cyclopedia, "Exotica."

According to Bailey (3) Coleus blumei Benth, (Coleus), is a native of Java belonging to the family Labiatae, occurring as an annual or a perennial herb. The common name Coleus will be used in this work.

Diseases of the Plants

The literature concerning plant disease of Ivyarum, P. oxycardium and "hastatum", and particularly fungus foliage diseases is meager. The majority of the available literature is generally confined to soil-borne organisms. Westcott (42) summarized them into the nematode (Radopholus similis) and Pythium splendens reported from Florida and Rhizoctonia sp. foot rot, reported from Missouri; the three organisms attacking Ivyarum.

The diseases of P. oxycardium and "hastatum" are reported under the general heading Philodendron spp. in the 1960 index (21) and the following are reported: a leaf spot reported from New Jersey, the Panama Canal Zone and Puerto Rico, caused by Colletotrichum philodendri P. Henn., Diplodia theobromae (Pat.) [illegible] wall on the stems, also reported from the Canal Zone. Meliola philodendri, F. L. Stev., a black mildew on the leaves, reported from Puerto Rico; Scolecopeltella microcarpa Speg., also on the leaves from Puerto Rico, and Thrichopeltis reptans (Berk. and Curt.) Speg., attacking the leaves, also reported from Puerto Rico.

Tisdale (41) reported promising results obtained in the control of Pythium sp. causing root rot of Ivyarum and P. oxycardium by using drenches of formaldehyde.

Munnecke and Chandler (30) reported a leaf spot related to the presence of molds on the ventral side of the leaves of "hastatum" related to the exudate of the stomata. They achieved some degree of control of the disease by controlling the fungus with Captan, but apparently the evidence was enough to determine the disease a physiological one.

The diseases of Coleus in the United States as reported in the index of Plant Diseases (20) are: Alternaria leaf spot in New Jersey; Badhamia panicea (Fr.) Rostr., a slime mold reported in Kansas; Botrytis cinerea Pers. ex Fr., a leaf spot and stem rot reported from Alaska. Phyllosticta sp., another leaf spot also from New Jersey; the crinkle, a non-infectious leaf deformity attributed to genetic factors, and a mosaic of the leaf, caused by an unidentified virus; these last two reported from various sources.

Bretz (7) reported a gray mold (Botrytis) attacking potted coleus plants and causing stem rot of cuttings, and foliage blight. He also added a leaf scorch, possibly of physiological origin, on an unidentified Philodendron sp. Bretz also reported an Oedema on P. oxycardium, also probably physiological in origin, producing corky intumescences on the foliage of the plants.

Chemicals

Captan was selected since it is a popular standard control for storage molds, as evidenced by the work of Stessel, as reported by de Ong ( ) and the study conducted by Shanks and Link (37). Fungus prevention, as advocated by Laurie (23), Pirone (33), Miller (28) and Baker *et al.* (4), was the major concern, and according to Martin (26), Captan is a powerful protectant fungicide particularly suitable for foliage applications, since there is no evidence of phytotoxicity.

Panogen and PMA are not only very powerful eradicants, as indicated by Martin (26) and Westcott (42) but also inhibitors of fungus growth. As inhibitors their use has been practically restricted to seed treatments as demonstrated by Olien and Moore (32) and Hsi (19). Their inhibiting character has been limited to seed treatment, probably because they may be phytotoxic as stated by Westcott (42) and Hsi (19).

PMA is a preventive fungicide of wide application and it performed very well inhibiting *Cladosporium* sp. growth on butter wrapped in parchment paper previously treated with PMA in Macy and Olson's (24) studies.

Bioquin was selected since according to Westcott (42), it is a promising fungicide for preventing fungi development and particularly so in foliage applications.

Captan. Haller and Simmons (16) reported Captan is a common name for the fungicidal chemical N-Trichloromethylthiotetrahydro Phthalamide, having the empirical formula $C_9H_8O_2NSCl_3$ and formerly designated Sr-406 or Orthocide, developed by the California Spray-Chemical Corp. Martin (26) adds that Captan was first described by Kittleson.

Panogen. According to Martin (26) Methylmercury Dicyandiamide has an empirical formula of $CH_3Hg.NHC(:NH).NH.CN$ and is also known to the trade as Panogen and Methylmercuric Cyanoguanicdine. Westcott (42) added the names Panodrench and Cyano Methylmercuriguanidine; and to these, McCallan et al. (27) added MMDD. Martin (26) indicated it has been used for seed disinfection under the name Panogen in Sweden since around 1938 and in North America since 1949. He indicated further that Panogen is a powerful fungicide for use on seeds of cereals, flax, sorghum, cotton and sugar beets. To these uses Westcott (42) added the control of damping-off of flower and vegetable seedlings and as an apple spray eradicant for scab. Martin (26) indicated Panogen is toxic to mammals and produces blisters if in prolonged contact with the skin.

Panogen, Phenylmercuric Acetate and Ceresan were tested and evaluated by Arny (2) in treating oat seeds and a 2.2 percent solution of Panogen proved superior to the other two fungicides tested.

Hsi (19) studied the toxicity of some mercurical seed disinfectants in wheat, and demonstrated that Panogen was less phytotoxic to wheat seeds than Ceresan.

Captan and Panogen were tried by Raabe and Sciaroni (35) in controlling damping off in various ornamentals. Panogen, used as a drench at two week intervals, gave excellent results and also controlled water molds on African violets and Gloxinias; additional tests are currently in progress.

Panogen drenches were used by Ark and Sibray (1) to control damping-off in nursery lots of carnations, begonias, marigolds, celosia, phlox, verbenas and zinnias where it proved very effective in controlling _Rhizoctonia solani_ and _Phythium ultimum._

PMA. Phenylmercuric Acetate, according to Martin (26) is an organic mercury compound having an empirical formula of Hg O C O CH_3. It has the following alternative names: PMA, PMAC, PMAS, TAG and HL 331. To these Westcott (42) added the following: Phix, Mersolite 8 (Berk). McCallan, et al. (27) indicated some more: Agrosan C, Agrox C, Gytrete, Isotox, Pontrete, Setrete, Mergamma C and Merlene. Martin added that PMA is a powerful eradicant fungicide, but of little protective value unless converted to the chloride. He indicates it is highly toxic to mammals. Westcott (42) reports that it is sold as PMAS for turf diseases, as Tag for apple scab and as Setrete for cereal seed treatment. For brevity and clarity the name PMA will be used in this work.

Olien and Moore (32) studied and compared PMA and Panogen in wheat seed treatment and demonstrated that both chemicals will inhibit seed-borne fungi in wheat seeds, but neither will kill the fungi.

de Ong (8) advocates the use of 1 1/2 ounce solution of PMA in five gallons of water per square foot of area, for the control of brown patch (*Pellicularia filamentosa* and *Rhizoctonia solani*) on turf grasses.

PNA. According to Frear (13) Sodium Propionate is sold under the name Chemicide PNA. The available literature on the use of PNA is more abundant in the Dairy and Food industries perhaps due to the fact that it is inocuous to humans, as pointed out by Macy and Olson (24). These workers studied the use of Calcium Propionate and Sodium Propionate in restraining mold growth on butter, by wrapping the butter samples in parchment paper previously treated with aqueous solutions, of predetermined percentages of both propionates. The butter had been previously inoculated by dipping in a mold-spore suspension of known species of *Alternaria*, *Cladosporium*, *Aspergillus* etc. The samples were stored after wrapping at 45° to 48° F. and 100 percent relative humidity. *Cladosporium* was detected eight days after treatment on the controls, and 12 days on the treated samples, when a 10 percent solution of Sodium Propionate was used to check mold development. Calcium Propionate was even more effective than Sodium Propionate in this particular case. The method has possibilities in wrapped foliage plants in transit or storage.

Wolford and Andersen (45) studied the germicidal, bactericidal and fungicidal properties of Sodium Propionate in preventing decay, microbial growth and mold development in berries in storage. Sodium Propionate gave excellent results as a fungus inhibitor in this case.

Nevertheless, PNA failed to control brown-rot disease (caused by Rhizopus sp.) in packed peaches when used as a post-harvest chemical dip treatment at non-injurious concentration, according to the study conducted by Heuberger, et al. (20).

Bioquin. According to Martin (26) Copper-8-hydroxiquin has an empirical formula of $Cu(OC_9H_6N)_2$ and is also known to the trade as Copper-8-hydroquinolinate, Copper-8-quinolinolate and Copper Oxinate (Oxine=8-hydroxyquinoline). Westcott (43) adds the trade name Bioquin, indicating it is an organic copper fungicide promising for powdery mildews and some other disease but too new for proper evaluation. Martin (26) adds that Bioquin is non-toxic to man and non-irritating to the skin. de Ong (8) also gives the name Cumulate for it.

Stoddard and Zentmer (40) demonstrated that at higher dosage levels and used as a drench, Bioquin injured peas, retarded emergence and caused chlorosis.

In a study conducted by Gill (15) Bioquin as such was used and also in several combinations with various wetting agents in controlling brown rot in unharvested peaches. Bioquin by itself allowed a 28 percent infection, while when used with the wetting agent Triton B it only permitted a 12 percent infection.

METHODS AND MATERIALS

The plants used in this experiment were: Philodendron oxycardium Schott (P. oxycardium); Scindapsus aureus (Lind. and Andre) Engl. (Ivyarum); Philodendron "hastatum" ("hastatum") and Coleus blumei Benth. (Coleus).

The fungicides applied were N-Trichloromethylthiotetrahydro Phthalamide (Captan); Methylmercury Dicyandiamide (Panogen); Phenylmercuric Acetate (PMA); Sodium Propionate (PNA) and Copper-8-hydroxiquin (Bioquin).

The 50 percent wettable powder formulation of Captan was used at the rate of .5 percent in an aqueous suspension. Panogen was used at a .002 percent rate of the commercial formulation (2.2 percent active ingredients); PMA at a .5 percent solution of the formulation (1.0 percent active ingredients). PNA, also as a 1.0 percent active formulation, was applied at the rate of .5 percent and Bioquin, pure powdered crystals was used as a 2 percent dust.

On October 15, 1960 approximately 200 one-eye cuttings of Ivyarum and the same number of cuttings of P. oxycardium were started to root in coarse vermiculite in a lean-to propagation greenhouse. The cuttings were grown under greenhouse conditions of 70 degrees F. and were watered every day.

One hundred fifty cuttings of Coleus were started on November 5, 1960, using a sterilized 1: 1: 1 (sand, peat and soil) mixture. On this same day another group of approximately 200 similar cuttings of Ivyarum, P. oxycardium and Coleus were set to root under the same conditions.

Pre-Trials

On December 10, 1960, all potted plants were moved to a warm 65 degrees F. greenhouse and a preliminary trial was run to determine the phytotoxicity of Panogen, PMA, Bioquin and Sodium Propionate.

Ten pots of each Ivyarum, P. oxycardium and Coleus were sprayed with Panogen at the rate stated previously.

A similar group of the three species was sprayed with PMA at the rate indicated.

Another group of ten plants of each species was dusted with Bioquin as previously stated and a fourth group sprayed with PNA, also at the same rate stated before. Each plant was then individually wrapped, as suggested by Dickey (9) and packed one replicate per carton in a two-ply corrugated paper box. The boxed plant material was stored at 70 degrees F. for a period of ten days. All plants were repotted and their survival rates determined.

Another pre-trial was run to determine if the Cladosporium spp. isolated from some P. oxycardium and Ivyarum plants would attack these two species and Coleus under simulated "in transit" conditions. Ten plants of each species were dipped in a mold-spore suspension of the two Cladosporium spp. After the foliage was dry, all plants were individually wrapped and grouped by species, packed in a box and stored. The plants were examined daily. On the 8th day, Cladosporium was detected on Ivyarum and P. oxycardium but no infection was found on Coleus.

Trials

Fungicide treatments were begun February 24, 1961. Three hundred seventy-five Ivyarum rooted cuttings were divided into fifteen lots of 25 plants each. Two lots of 25 plants each were handled as replicates, by spraying with Captan as stated, using a compressed air, 2 gallon Hudson Sprayer. The foliage was allowed to dry and the plants were then inoculated by dipping their foliage in a mold-spore suspension of the two Cladosporium spp. made by crushing four agar cultures of the organisms in five gallons of water. The foliage was permitted to dry and shipping conditions were simulated by wrapping each individual plant in one sheet of newspaper and storing each replicate in a two ply corrugated carton. A third group of 25 plants similarly inoculated but without fungicide treatment, was identically processed and served as a control. The packed plant material was stored at 70 degrees F.

The plants were observed daily and readings taken, beginning on the eighth day of incubation, for three consecutive days. Records included the percentages of plants infected, percentage leaf surface infected and number of leaves attacked. A set of standards was established to measure the progress of the infection. The method used by Yarwood (46) was rendered useless by the pattern of mold development.

A 50 percent leaf area infection was estimated, for any moldy area as determined by the midrib of the leaf, whether the infection was on either the dorsal or the ventral side. Approximately half of that area was estimated as 25 percent and 75 percent for approximately three fourths of either the dorsal, or the ventral side of the leaf. The plants were observed daily for a period of 10 days.

The same procedure was repeated with Ivyarum using the fungicides at the same rates. The trials with P. oxycardium were run simultaneously with the Ivyarum following the same procedures outlined, except that 18 plants per replicate and control were used in the latter case.

The Coleus plants were treated March 29, 1961 following the same procedures. Coleus failed to show any fungus growth after a period of 7 days of observation when the trial was ended since the plants were severely wilted.

All Ivyarum, P. oxycardium and Coleus plants were repotted after the experiment to observe survival.

The "hastatum" trial was conducted with 375 "hastatum" plants obtained from a commercial grower in Puerto Rico. The plants left the San Juan International Airport April 3, 1961 "clean of pathogenous fungi," according to the quarantine certificate of inspection and arrived at the Manhattan Airport four days later, April 7, 1961. The plants were potted in 6 inch clay pots using a 1 - 2 - 1 sterilized mixture of sand, manure and soil. These were rooted cuttings of excellent quality, and had been expertly handled in the packing process. Their root systems were closely packed in wet sphagnum moss, and wrapped two per bunch using a double newspaper, holding the moss closely packed to the roots. On the day of arrival, twenty of the hastatum plants showed some mold infection. In every case the molds were confined to the ventral side of the leaf, confirming Munnecke's and Chandler's (30) experience with molds on "hastatum."

The fungi were isolated, identified and cultured on agar by Dr. Charles L. Kramer of the Department of Botany and Plant Pathology, Kansas State University. The fungi were identified as a Nigrospora sp. and a Graphium sp.

The trial with "hastatum" was started May 5, 1961 following the procedures used for the previous cases except that the mold-spore suspension included both Cladosporium spp. previously used, plus Graphium and Nigro spora in the inoculum.

In the case of "hastatum", the standards used to estimate percent of leaf area infection as used for Ivyarum and P. oxycardium could not be applied. The pattern of growth of the fungi on "hastatum" was much slower. Only the percentage of plants infected were recorded (Table 1).

All "hastatum" plants were repotted and survival observed. The data regarding the Ivyarum, P. oxycardium and "hastatum" fungicide trials are presented in Tables 1, 2, and 3.

RESULTS AND DISCUSSION

Pre-trials: In the pre-trial to determine phytotoxicity, all Ivyarum, P. oxycardium and Coleus plants were uninjured by treatments with Panogen, PMA, PNA and Bioquin at the rates used. Most of the Ivyarum and P. oxycardium plants were attacked by the two Cladosporium spp. in the inoculation pre-trial causing severe defoliation that would have rendered the plants unsalable. No Coleus plants were attacked by these.

Trials: The data recorded on the trials conducted with Ivyarum, P. Oxycardium and "hastatum" related to the percentage of plants attacked by molds, are summarized in Table 1.

Shown in Table 1, Cladosporium spp. growth was first detected in the controls and in some of the treated replicates on the 8th day of incubation. This is in agreement with Macy and Olson's (24) results on their study of mold control in butter. Nigrospora and Graphium were first detected in "hastatum" also on the eighth day of incubation. The percentage of plants infected was always higher in the controls showing that some degree of inhibition was achieved in all cases.

The statistical analysis revealed that the only significant, positive difference was obtained by PMA and Panogen on the 9th and 10th day of Ivyarum and P. oxycardium. Panogen and PMA apparently inhibited mold growth in all species suggesting achievement of a perfect control, but other differences were not significant.

Table 1. Percentage of plants infected and index of infection.

Treatmen		Panogen			Captan			PMA			PNA			Bioquin		
Species	Days	Treat	Cont.	Index	Treat	Cont.	Index	Treat	Cont.	Index	Treat	Cont.	Index	Treat	Cont.	Index
Ivyarum	8th	0	27	27	8	33	25	0	22	22	0	28	28	11	33	22
	9th	0	50	50	17	55	38	0	61	61	5	55	50	25	55	30
	10th	0	88	88	27	83	56	0	94	94	8	100	92	45	100	55
P. oxycardium	8th	0	28	28	10	28	18	0	32	32	6	28	22	[illegible]	[illegible]	2
	9th	0	48	48	22	48	26	0	44	44	16	52	36	46	48	2
	10th	0	100	100	48	100	52	0	100	100	36	100	64	100	100	0
"hastatum"	8th	0	4	4	4	8	4	0	4	4	0	4	4	6	12	6
	9th	0	12	12	4	20	16	0	16	16	0	24	24	18	24	6
	10th	0	32	32	10	28	18	0	36	36	2	40	38	34	44	10

Significant differences are underlined.
l.s.d. = 32 percent at the .05 level, Kalmogorov - Smirnov test, Siegel (38).
The index of infection is the percentage of plants infected in the controls minus the average percentage of plants infected in the treatments.

In order to rank the fungicides according to their performance as mold inhibitors, the data in Table 1 was used as a basis for a statistical analysis of variance by ranks using the Friedman's test, as indicated by Siegel (38). They were ranked from low to high, using the digit 1 for the lowest in the rank.

The fungicides were ranked within the species for each day, to determine if the same fungicide gave the same rank with all the species.

These results are summarized in Table 2.

Table 2. Ranking the fungicides within the species for each day after treatments and showing significant differences, Friedman's two way test, Siegel (38).

Treatment	Panogen Index	Panogen Rank	Captan Index	Captan Rank	PMA Index	PMA Rank	PNA Index	PNA Rank	Bioquin Index	Bioquin Rank
8th Day										
P. oxycardium	27	4	25	3	22	1.5	28	5	22	1.5
Ivyarum	28	4	18	2	32	5	22	3	02	1
"hastatum"	04	3.5	04	3.5	04	3.5	04	3.5	06	5
							$X^2_r = 1.2$ n.s., df.=4			
							X^2,.05, df. 4=9.49			
9th Day										
P. oxycardium	50	3.5	38	2	61	5	50	3.5	30	1
Ivyarum	48	5	26	2	44	4	36	3	02	1
"hastatum"	12	2	16	3.5	16	3.5	24	5	06	1
							$X^2_r = 7.9$ n.s., df.=4			
							X^2,.05, df. 4=9.49			
10th Day										
P. oxycardium	88	3	56	2	94	5	92	4	55	1
Ivyarum	100	4.5	52	2	100	4.5	64	3	0	1
"hastatum"	32	3	18	2	36	4	38	5	10	1
							$X^2_r = 10.2$ sig. df.=4			
							X^2,.05, df. 4 = 9.49			

Significant differences are underlined.

On the eighth day the numbers were too variable to have any statistical meaning, however Bioquin shared last ranking with PMA. On the ninth day Bioquin ranked last, demonstrating a trend had been statistically shown. There were no significant differences between Panogen, PMA and PNA on the eighth or ninth day. On the tenth day, Panogen, PMA and PNA showed a positive significant difference over Captan and Bioquin, with Bioquin ranking last and Captan next to last. No significant differences were shown among Panogen, PMA, and PNA.

The progress of infection on P. oxycardium and Ivyarum and the number of leaves infected are presented in table 3.

No data are shown for Coleus because the plants were not attacked by fungi. No data are shown for "hastatum" since percentage of leaf area infected was small and not recorded.

No fungus infection could be detected in any of the leaves of Ivyarum or P. oxycardium plants in the Panogen treatment nor the PMA treatment.

The data regarding percentage of leaf area infection and number of leaves are shown only to illustrate the magnitude of the infection.

The results on percentage of plants infected were used for the statistical analysis since the major concern was the quantity of plants made unsalable by mold attack.

Survival rates: All Ivyarum, P. oxycardium and "hastatum" plants survived the treatments in the pre-trial to determine phytotoxicity. The Coleus plants showed a 98 percent survival, but the loss was due to mechanical injury.

In the inoculation pre-trial the majority of the Ivyarum and P. oxycardium plants were attacked by the two Cladosporium spp. causing severe defoliation that would have rendered the plant material unsalable.

SUMMARY

This study was conducted to find a preventive fungicidal treatment to inhibit fungus growth on foliage plants in transit.

The plants used were Scindapsus aureus (Lind. and Andre) Engl. (Ivyarum); Philodendron oxycardium Schott (P. oxycardium); Philodendron "hastatum"

Table 3. Progress of infection on P. oxycardium and Ivyarum expressed in percent of leaf area and total number of leaves infected.

		Ivyarum										P. oxycardium									
		Treated					Control					Treated					Control				
		25%	50%	75%	100%	TL	25%	50%	75%	100%	TL	25%	50%	75%	100%	TL	25%	50%	75%	100%	TL
Lanogen																					
Days:	8th	-	-	-	-	-	4	4	4	2	14	-	-	-	-	-	-	4	6	4	14
	9th	-	-	-	-	-	6	10	2	6	24	-	-	-	-	-	6	4	6	2	18
	10th	-	-	-	-	-	16	16	8	10	50	-	-	-	-	-	6	16	8	2	32
Captan																					
Days:	8th	4	2	4	-	10	6	4	2	2	14	6	-	-	-	6	6	4	2	-	12
	9th	8	2	6	6	22	4	12	2	6	24	2	8	2	-	12	6	8	2	4	32
	10th	30	24	16	24	94	18	16	8	8	50	-	14	6	-	20	8	16	-	6	30
PMA																					
Days:	8th	-	-	-	-	-	4	6	6	2	18	-	-	-	-	-	4	2	2	-	8
	9th	-	-	-	-	-	4	10	4	4	22	-	-	-	-	-	8	10	-	4	22
	10th	-	-	-	-	-	12	18	12	8	50	-	-	-	-	-	16	6	4	8	34
EMA																					
Days:	8th	6	-	-	-	6	6	2	4	2	20	12	6	2	-	40	6	4	2	-	12
	9th	8	6	2	-	16	6	10	4	6	42	12	12	10	2	36	6	8	2	4	20
	10th	14	12	6	2	34	18	16	8	8	50	22	22	12	10	44	16	6	6	8	36
Bioquin																					
Days:	8th	8	10	6	2	26	6	2	4	1	15	12	6	2	-	20	6	4	2	-	12
	9th	10	20	8	8	46	4	12	2	6	24	12	12	10	2	36	6	8	2	4	20
	10th	34	30	18	18	100	12	18	12	8	50	22	22	12	10	66	16	6	6	8	36

TL = Total number of leaves infected.

("hastatum"); and Coleus blumei Benth., (Coleus). The fungicides used were: Captan, Panogen, PMA, PNA and Bioquin.

The 50 percent wettable powder formulation of Captan was used at the rate of .5 percent in an aqueous suspension. Panogen was used at a .002 percent rate of the commercial formulation (2.2 percent active ingredients); PMA at a .5 percent solution of the formulation (1.0 percent active ingredients). PNA also as a formulation 1.0 percent active, was applied at the rate of .5 percent and Bioquin (100 percent) was used as a 2 percent dust.

The first trials were run with Ivyarum, P. oxycardium and Coleus. Two replicates of each plant species were treated with the fungicides and inoculated. A third lot, inoculated without treatment served as controls. The number of plants in each replicate was 25 for Ivyarum and Coleus, and 18 for P. oxycardium. The inoculum used in these trials was a mold-spore suspension of two Cladosporium spp. found attacking Ivyarum and P. oxycardium plants in the greenhouse. The plants in the replicates were first treated with the chemicals at the rates indicated and then inoculated by dipping in the inoculum. Each treated plant was individually wrapped in a sheet of newspaper and each replicate packed in a 2 ply corrugated paper box and stored under simulated "in transit" conditions. The control plants were similarly inoculated but without treatment and similarly processed. Daily observations were made and results, expressed in percentage of plants attacked by the organism, percentage leaf surface infected, and number of leaves attacked were recorded for three consecutive days, beginning on the 8th day of incubation when molds were first detected.

These trials indicated Ivyarum and P. oxycardium susceptible to the two Cladosporium spp. and indicated Coleus immune to these organisms.

The "hastatum" trial was conducted with plants shipped from a commercial nursery in Puerto Rico. The two replicates were treated first with each fungicide and then inoculated by dipping in a mold-spore suspension of the two Cladosporium spp. used previously plus a Nigrospora sp. and a Graphium sp. obtained from the "hastatum" plants upon their arrival. They were processed using the same methods as the previous trials.

This trial indicated "hastatum" immune to Cladsporium spp. and susceptible to Nigrospora sp. and Graphium sp. The mold growth in "hastatum" was slower than in the previous trials and it was confined to the dorsal side of the leaf blades.

Panogen, PMA and PNA showed a positive significant difference over Captan and Bioquin, with Bioquin ranking last and Captan next to last. No significant differences were shown among Panogen, PMA and PNA.

Mold infection in Ivyarum and P. oxycardium was severe and although a high degree of defoliation occurred making these plants unsalable, all the plants survived the attack of the fungi.

Panogen, PMA, PNA and Bioquin were non-toxic to the plants at the rates used.

The only significant, positive difference was obtained by PMA and Panogen on the 9th and 10th day on Ivyarum and P. oxycardium and although Panogen and PMA apparently inhibited mold growth in all species suggesting achievement of a perfect control, other differences were not significant.

CONCLUSION

A thorough review of the literature failed to reveal any previous study conducted with these specific objectives with foliage plants in general and these species in particular; so it might be reasonably concluded that this is the first study ever conducted covering this area of research. This is the first time *Cladosporium* spp. are reported attacking Ivyarum and *P. oxycardium*, both in the greenhouse and under simulated "in transit" conditions. This also the first time *Nigrospora* sp. and *Graphium* sp. are reported on "hastatum" shipped from Puerto Rico and also under simulated "in transit" conditions. Ivyarum and *P. oxycardium* indicated susceptibility to two *Cladosporium* spp. and the molds attacked the dorsal, the ventral side or both sides of the leaf blades.

Coleus and "hastatum" indicated resistance to the two *Cladosporium* spp. and "hastatum" indicated susceptibility to a *Nigrospora* sp. and a *Graphium* sp. The infection in this last case was restricted to the dorsal side of the leaves.

Panogen, PMA, PNA and Bioquin were found to be non-toxic to any of the species at the rates applied.

Panogen, PMA and PNA showed a positive significant difference over Captan and Bioquin, with Bioquin ranking last and Captan next to last. No significant differences were shown among Panogen, PNA and PMA.

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FUNGUS CONTROL OF WRAPPED FOLIAGE PLANTS

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The objective of this experiment was to find a preventive fungicidal treatment for fungus growth on foliage plants in transit.

Rooted cuttings of *Philodendron oxycardium* Schott; *Scindapsus aureus* (Lind. and Andre) Engl. (Ivyarum), *Coleus blumei* Benth (Coleus) and *Philodendron "hastatum"* ("hastatum") were used in the trials.

The fungicides tested were: Methylmercury Dicyandiamide (Panogen); Trichloromethylthiotetrahydro Phthalamide (Captan); Phenylmercuric Acetate (PMA); Sodium Propionate (PNA) and Copper-8-hydroxiquin (Bioquin). The 50 percent wettable powder formulation of Captan was used at the rate of .5 percent in an aqueous solution. Panogen was used at a .002 percent rate of the commercial formulation (2.2 percent active ingredients); PMA at a .5 percent solution of the formulation (1.0 percent active ingredients). PNA, also as a formulation 1.0 percent active, was applied at the rate of .5 percent and Bioquin (100 percent pure) was used as a 2 percent dust.

Two replicates of each of the three plants species were treated with each of the chemicals. Five untreated replicates served as the controls. The number of plants in each replicate was 25 for Ivyarum and Coleus and 18 for *P. oxycardium*. The inoculum used was a mold-spore suspension of two *Cladosporium* spp. found attacking Ivyarum and *P. oxycardium* plants in the greenhouse. The plants in the replicates were first treated with the chemicals and allowed to dry, then inoculated by dipping in a spore suspension in water. Each individual plant was then wrapped in a sheet of newspaper and each replicate packed in a two ply, corrugated paper box and stored under simulated "in transit" conditions. The controls were similarly inoculated but without fungicide treatment and similarly processed. Daily observations were made and results expressed in terms of percent of the plants attacked, percentage leaf surface and number of leaves attacked by the fungi were recorded for three consecutive days, beginning on the 8th day of incubation when mold growth was first detected.

This trial indicated Ivyarum and P. oxycardium susceptible to the two Cladosporium spp. and Coleus immune to these fungi.

Panogen, PMA and PNA proved equally effective in inhibiting fungus growth in the plants while Bioquin consistently failed to do so.

The "hastatum" plants were obtained from a commercial grower in Puerto Rico. Two "hastatum" replicates were treated with fungicide and then inoculated by dipping in a mold-spore suspension of the two Cladosporium spp. previously used, plus a Nigrospora sp. and a Graphium sp. obtained from the "hastatum" plants upon their arrival.

This trial indicated that "hastatum" was immune to Cladosporium spp. but susceptible to Nigrospora sp. and Graphium sp. The molds on "hastatum" grew at a much slower rate than those on the previous species, and their attack on "hastatum" was restricted to the dorsal side of the leaf blades.

Mold infection in Ivyarum and P. oxycardium was severe causing a high degree of defoliation but all plants in both cases survived the attack.

Panogen, PMA, PNA and Bioquin were non-toxic to these plant species at the rates used.

The only significant differences were obtained with Panogen and PMA on the ninth and tenth days in the cases Ivyarum and P. oxycardium, although the two fungicides gave good prevention of mold invasion in all cases, other differences were not significant. Panogen, PMA and PNA showed a positive significant difference over Captan and Bioquin, with Bioquin ranking last and Captan next to last. No significant differences were shown among Panogen, PMA and PNA.