Control of Rust of China Aster and Comments on the Name of the Pathogen[1]

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Abstract

Rust, *Coleosporium asterum*, of China aster, *Callistephus chinensis*, is a serious problem on plants grown for cut flowers in California. Control of the rust resulted from 3 applications of fungicides at 3-week intervals. Funginex® (triforine) gave the best control. Bayleton® (triadimefon) and Fore® (mancozeb) gave good control. Plantvax® (oxycarboxin) and Physan® (a quanternary ammonium chloride compound) failed to control the fungus satisfactorily. The use of the binomial *Coleosporium asterum*, formerly called *C. solidaginis*, is questioned.

Index words: Rust, aster, rust control, *Coleosporium asterum, Coleosporium solidaginis*

Significance to the Nursery Industry

In this paper it is shown that aster rust control can result from several concentrations of Funginex® (triforine) and that the low rate was not significantly different than the high rate. The low rate also was only 65% the rate used in the eastern U.S. but still gave effective control, even though in the eastern U.S. the sprays were put on once every 10 days and in these experiments they were applied once every three weeks. Bayleton® (triadimefon), even at higher rates, did not give as good control as it did in the eastern U.S., probably due to the longer intervals between sprays. The actual identity of the fungus is discussed and information is presented indicating that it is not *Coleosporium asterum*, a fungus with a very wide host range.

Introduction

The China aster, *Callistephus chinensis* L., sometimes referred to as aster, is grown commercially as a cut flower throughout much of the year in areas bordering San Jose, California. Land for growing asters in that area is becoming more difficult to find due to housing and the soil-infesting fungus *Fusarium oxysporum* Schlect. pv. *callistephi* (Beach) Snyd. & Hans. Control of the fungus by soil fumigation, though successful (20), cannot be used because of the proximity of homes. Because of the shortage of growing space, seed beds for starting plants and areas for growing the flowers were adjacent and spores of the rust fungus *Coleosporium asterum* (Diet.) P. & H. Snydow from mature plants infected the seedlings. The fungus continued to develop and spread after transplanting of the seedlings so that by the time of harvest, leaves, flower stalks and involucral bracts were so infected the flowers were not saleable. Outbreaks were so severe as to threaten the production of cut-flower asters as a commercial enterprise. Fungicidal control was considered the best approach.

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In previous control experiments, it was shown that Sulfodust, Green Kolodust, flotation sulfur spray and 3-1½-50 Bordeaux (1) or zineb (11) gave control. These materials were not considered because of residue problems. More recent research showed that Baycor® (bitertanol), Bayleton® (triadimefon), and Funginex® (triforine) gave good control (5). However, because these experiments were done on the East Coast under completely different environmental conditions and because the spray interval of 10 days seemed excessive to the growers, an experiment was started to determine what might be successful on the West Coast.

Materials and Methods

Experiment 1. Spraying was started in an aster field on infected plants which had not started to flower. Each treatment was replicated three times on plots 0.92 m × 2.76 m (3 × 9 ft), consisting of 3 rows of plants per bed. Cultivars of these asters are not known because each grower selects seed from his own plants. Fungicides were applied with a 2-gallon Hudson sprayer 4 times at 3-week intervals beginning September 11. Plants were sprayed to run-off. Fungicides included Funginex® (triforine 20% EC), Bayleton® (triadimefon 50% W); Plantvax® (oxycarboxin 75% W), and Fore® (mancozeb 80% W). Treatments and results are given in Table 1. Only plants in the center rows were rated to avoid buffer effects.

Experiment 2. A second experiment was started eight months later. In this experiment, several triforine formulations were used from each formulator. Also included were Bayleton® (triadimefon), Fore® (mancozeb) and Physan® (a quaternary ammonium chloride compound 20%). Fungicides were applied 3 times at 3-week intervals (beginning May 9) except Fore® (mancozeb) and Physan®, which were applied at weekly intervals for 6 weeks. Plants were rated 5 days after the last spray application. As before, plots were 3 row beds and were 0.92 × 2.76 M (3 × 9 ft) and only plants in the center rows were rated. Treatments and results are given in Table 2.

Results and Discussion

In the first experiment, Funginex® (triforine) gave the best control and Bayleton® (triadimefon) gave next best

Table 1. Effectiveness of four fungicides in controlling rust of China aster when sprayed 4 times at 3-week intervals.

Treatment	Con/liter	infected leaves/plant	leaves infected/plant	rust infections/leaf
		#	%	#
Funginex® 20 EC (triforine)	0.74 ml	0.5 a[z]	2.5 a[z]	2.0
Bayleton® 50 W (triadimefon)	0.60 gm	3.2 b	16.2 b	2.2
Plantvax® 75 W (oxycarboxin) + Fore® 80 W (mancozeb)	1.32 gm + 2.40 gm	13.9 c	74.5 c	9.0
Plantvax® 75 W (oxycarboxin)	1.32 gm	15.8 d	83.9 d	10.5
Fore® 80 W (mancozeb)	2.40 gm	17.8 e	96.3 e	81.7
Non-sprayed check		18.82 e	100.0 e	85.0

[z]Numbers with the same letters do not vary significantly according to Duncan's Multiple Range Test (P = 0.05).

control (Table 1). Plantvax® (oxycarboxin), effective in controlling some rusts, did not give satisfactory control so was not included in the second experiment. Fore® (mancozeb) also did not give good control, but it was requested that it be included in the second experiment at a more frequent spray interval. In the second experiment, triforine again gave the best control in all formulations tested. The 20% EC FMC formulation at the low rate resulted in control which was significantly different from the others in the average number of leaves infected and the percentage of leaves infected per plant. No injury was observed with any of the materials.

In the experiments reported here, triforine (called Funginex® by one of the formulators) consistently (except for the low rate of one of the formulations) gave the best control. This differs from the results of Clarke & Peterson (5) who found that triforine did not differ significantly from any of the three concentrations of Bayleton® (triadimefon) used. The low rate of Bayleton® (triadimefon) used in these experiments corresponded to the high rate used by Clarke and Peterson but failed to give as good control as most of the triforine treatments; the same was true of the high rate which was two times that of their high rate. However, Clarke and Peterson sprayed every 10 days and in the experiment reported here, triforine and Bayleton® (triadimefon) were sprayed every three weeks. Differences also might be accounted for by the difference in climate between the East and West Coasts. In addition, it is possible that there is a difference in the strains of the rust fungus which occur on China asters in the east and in the west.

Comments on the Name of the Pathogen

In regard to the causal agent, there is a great deal of confusion as to the name of the fungus. An uredial stage was first described by Schweinitz (22) in 1822 on species of *Aster, Solidago* and *Vernonia* as *Uredo solidaginis*. In 1878, von Thumen (25) described a telial stage on two species of *Solidago* in New Jersey and named the causal rust *Coleosporium solidaginis*. The aecial stage was described as *Peridermium acicolum* by Underwood and Earle (24) on *Pinus rigida* Mill. in 1896, and in 1907, Clinton (6) showed that *P. acicolum* is the aecial stage of *C. solidaginis* by using aeciospores from *P. rigida* to infect *Solidago rugosa* Mill. by inoculation.

Arthur and Kern (4) described a new rust on lodgepole pine (*P. contorta* Loud.) in Montana in 1906 and named it *Peridermium montanum*. Hedgecock (13) found a rust on *Aster* spp. near those pines and speculated it was the same rust. In 1916 (14) he showed that the aeciospores from lodgepole pine infected a species of *Aster*, leading him to believe that the rust fungus on pine in the west (*P. montanum*) was the same fungus as the rust fungus on pine in the eastern U.S. (*P. acicolum*) because of the similarity of their teliospores. He assigned the western form to the same species as the eastern form and called them *C. solidaginis*. Also in 1916, Weir and Hubert (27) made inoculations in

Table 2. Effects of four fungicides on the control of rust of China aster when sprayed three times at three-week intervals.

Treatment	Con/L	infected leaves/plant	leaves infected/plant	sori/leaf
		#	%	#
Funginex® 20 EC Ortho (triforine)	1.48 ml	.27 a[z]	1.10 a[z]	.53 a[z]
Funginex® 20 EC Ortho (triforine)	.74 ml	.64 a	3.50 a	.64 a
triforine 20 EC FMC	1.48 ml	.58 a	2.36 a	1.80 a
Funginex® 6.5 EC Ortho (triforine)	4.55 ml	.84 ab	2.73 a	1.49 a
Funginex® 6.5 EC Ortho (triforine)	2.27 ml	1.16 abc	5.17 a	3.73 a
Bayleton® 50 W (triadimefon)	1.20 gm	2.09 bcd	8.68 bc	5.89 a
Fore® 80 W[y] (mancozeb)	2.40 gm	2.42 cd	9.51 bc	25.76 a
Bayleton® 50 W (triadimefon)	.60 gm	2.58 d	10.58 c	6.71 a
triforine (20 EC FMC)	.74 ml	2.89 d	10.74 c	15.82 a
Bayleton® 50 W (triadimefon)	.30 gm	10.62 e	39.52 d	78.60 b
Physan® 20%[y] (quaternary ammonium chloride)	.66 ml	22.53 f	73.94 e	344.22 c
Untreated check		21.96 f	90.33 f	848.78 d

[z]Numbers followed by the same letter are not significantly different according to Duncan's Multiple Range Test (P = 0.05).

[y]Fungicides sprayed weekly instead of every 3 weeks.

Montana from the *Peridermium* on pine to several plants and were successful in infecting 2 species of *Solidago* and one species of *Aster*. This was the first successful inoculation of *Solidago* species and as a result, they confirmed that the fungus with which they were working was *C. solidaginis*.

In 1922, Hedgecock and Hunt (16), working in the eastern U.S., found through inoculations that *C. solidaginis* infected only *Solidago* spp. (142 species of 241 tried) and not any *Aster* spp. or *Callistephus chinensis* Nees. They suggested that either there were 2 races of *C. solidaginis*, one infecting *Solidago* spp. and the other infecting *Aster* spp., or that the *Coleosporium* on aster was a species other than *C. solidaginis*.

Working in Montana, Weir (26) made successful cross-inoculations using uredospores from *Aster* and *Solidago* spp. of what he termed the western rust. He stated that similar experiments had not been performed on the eastern form. Because of this and because of the differences in the aeciospores as described by Arthur and Kern (4), he felt the eastern and western forms should be regarded as distinct species.

Nichols et al. (18) working in Wisconsin reported three forms of the rust. One infected *Solidago canadensis* L. but not *Aster macrophyllus* L. Another from *S. altissima* L. infected cultivated perennial *Aster* spp. (unnamed) but not *A. macrophyllus* or cultivated annual asters (genus and species not listed) and one rust from *A. macrophyllus* which infected cultivated annual asters and *A. macrophyllus* but not *S. canadensis* or cultivated perennial asters. If the annual asters of Nichols et al. were the China aster, *Callistephus chinensis*, then they are the first to report the infection of that plant in North America following inoculation with *Coleosporium asterum*.

In North America, the rust on *C. chinensis* was reported as early as 1898 (12) and was listed as a *Coleosporium* spp. In 1924, Gloyer (10) used the name *C. solidaginis* to describe the rust on *C. chinensis*. Hedgecock (15), in his report of *Coleosporium* spp., collected the rust on *C. chinensis* from 11 eastern states and one Canadian province and listed the causal agent as *C. solidaginis*. Arthur (2) listed the rust on *C. chinensis* as *C. solidaginis*, as did Arthur and Cummins (3), although Cummins (7) changed the name to *C. asterum* (Diet.) Sydow. No report could be found of *C. chinensis* being infected in North America as a result of being inoculated with *Coleosporium asterum* (*C. solidaginis*) except for the possible report of Nicholls et al. (18) in which they did not list the genus or species of the annual asters used.

In 1898 in Japan, Dietel (9) described a rust on *Callistephus chinensis, Aster scaber* Thunb., *A. tataricus* L.f and *A. indicus* L. (later changed to *Kalimeris yomena* Kitam.). Because of the teliospores, he believed the rust to be different from *Coleosporium*, so he erected a new genus, *Stichopsora*, and named the fungus *S. asterum*. No pine hosts were listed. In 1914, Sydow and Sydow (23) changed the name to *C. asterum*. In a very thorough study of the pine needle rusts of Japan, Kaneko (17) showed that the teliospores of the rust on *C. chinensis* and *A. scaber* were similar, but they differed from the teliospores of the rust on *A. tataricus*, the latter of which had been designated the lectotype of *C. asterum* by Cummins (8). Kaneko also showed that the teliospores on *C. chinensis* and *A. scaber* were somewhat similar to the teliospores of *C. pini-asteris* Orishimo, described in 1910 (19) as occurring on *A. scaber*. Kaneko also showed, by inoculation, that the uredospores from *A. scaber* infected the leaves of *C. chinensis*. The correct name for the fungus on *C. chinensis* in Japan must be *C. pini-asteris*. Kaneko also showed, however, that the *Coleosporium* on *C. chinensis* from the United States and Canada differs from the rust on that plant in Japan, leading him to conclude that further research is necessary to identify the rust on *C. chinensis* in North America.

In addition, Kaneko compared specimens of *C. asterum* from *Aster* and *Solidago* spp. from eastern and western North America with those of Japan and concluded that *C. asterum* in North America should be treated as 2 species and that they are different from *C. asterum* and *C. pini-asteris* of Japan. He stated that additional research also is needed to identify these rusts in North America.

It should be mentioned that in Europe, a rust on *C. chinensis* has been reported as *Puccinia callistephi* (21). This also should be included in the research to determine the identity of the rust or rusts on *C. chinensis*.

(**Ed. note:** This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this paper, be certain of their registration by appropriate state and/or federal authorities.)

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Growth of Capillary-Irrigated Andorra Juniper and Sarcoxie Euonymus as Affected by Controlled Release Fertilizer Type and Placement[1]

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Abstract

Juniperus horizontalis Moench. 'Plumosa compacata' and *Euonymus fortunei* Turcz. 'Sarcoxie' were grown on a sand capillary bed with two types of controlled release fertilizer (3:1 Type 100:Type 40 Nutricote 16N-4.4P-8.1K (16-10-10), and Osmocote 18N-2.6P-9.7K (18-6-12) either medium-incorporated, surface-applied or dibbled below the roots. Throughout the growing season, neither leaf area, root or shoot dry weight of euonymus was affected by fertilizer type or placement. Branch length growth and dry weight of juniper was not affected by fertilizer type when fertilizer was surface-applied or medium incorporated. Dibbled Osmocote produced similar results, but dibbled Nutricote resulted in poor root and shoot development in juniper throughout the season. Medium soluble salt concentration (determined on container leachate) was 2800 dS/m in the dibbled Nutricote treatments in June (approximately 2.5 times higher than that in the other treatments). Soluble salts decreased between June 21 and August 16 in all treatments and then remained quite constant until the end of the season (September 13).

Index words: sand bed, containers, soluble salts

Significance to the Nursery Industry

As concerns over water consumption, quality and ground water contamination increase, capillary irrigation of nursery stock is likely to gain importance. Nutricote or Osmocote controlled release fertilizers which are either premixed or applied to the surface of the growing medium promote good growth of compact andorra juniper and sarcoxie euonymus on capillary systems. Dibbling should be used with caution especially when dealing with salt sensitive species, since rapid nutrient release can result in soluble salt accumulation in the early season.

Introduction

Capillary, or sub-irrigation is a popular irrigation method for container production in nurseries in various countries especially where water consumption and quality is a critical consideration (2, 7, 10). Considerably, less water is required with capillary, than with overhead irrigation. Moreover, water is more evenly distributed in the container thus reducing the potential for waterlogging and leading to improved plant growth (7, 11).

Fertilization via irrigation water is not practical with capillary systems, so their successful operation dictates the use of controlled release fertilizers applied to containers at the start of the season. Since water moves upward through the growing medium, it might be concluded that application of fertilizer to the medium surface would not be effective in sustaining nutrient supply in the root zone. Where fertilizers are medium-incorporated limited leaching might result in soluble salt accumulation leading to a reduction in growth. An alternative might be to dibble fertilizer in a zone just below the developing root system where an adequate water supply and the presence of developing roots should result in rapid uptake of nutrients (1). Previous research has compared the effects of fertilizer type and surface, incorporated

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