The Occurrence of root rot disease complex of alstroemeria in Alberta

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The incidence and severity of alstroemeria root rot disease complex was determined for 15 cultivars from seven commercial greenhouses in Alberta in 1990. Among cultivars, the highest disease incidence (DI) occured on Orange Monarch (67.9%) while the highest disease severity (DS) rating was observed on Saxony (47%). The lowest DI and DS values occurred on Paloma (16.6% and 11% respectively). The pathogens most frequently isolated from cultivars in the greenhouses examined were *Fusarium* spp. and to a lesser extent Pythium spp. and *Rhizoctonia* solani. The rate of simultaneous infection of alstroemeria by *Fusarium* spp. and *R.* solani was higher than any of the other possible pathogen combinations.

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En 1990, l'incidence et la virulence du pourridié s'attaquant à l'alstroemeriaont été determine a partir de quinze cultivars provenant de sept serres commerciales de l'Alberta. Parmi les cultivars, l'incidence la plus élevée de la maladie (DI) a été relevée dans le cas du cultivar Orange Monarch (67.9 %) alors que le degre de virulence le plus élevé (DS) de la maladie a été observe chez le cultivar Saxony (47 %). Les valeurs DI et DS les plus basses ont été enregistrees pour le cultivar Paloma (16.6 *Y.* et 11 % respectivement). Les pathogenes les plus fréquemment isolés lors de l'examen en serres de ces cultivars, ont été *Fusarium* spp. Les pathogenes Pythium spp. et *Rhizoctonia solani* ont également été isolés, mais en moins grande quantité. Le taux d'infection simultane de l'alstroemeriapar *Fusarium* spp. et *R. solani* a été plus élevé que n'importe quelles combinaisons possibles de pathogenes.

Introduction

Lily-of-the-Inca or Peruvian lily *(Alstroemeria* spp.) originated from plants collected in South America. Commercial cultivars of alstroemeria are popular as cut flowers in many countries because of their low energy requirement for growth and the excellent keeping quality of the flowers (6,8,11,14; Fig. 1). The flower type and growth characteristics have been used to describe four categories of plants: orchid, butterfly, in-between, and carmen **(8).** Practices for improving the floral production of alstroemeria have concentrated primarily on elucidating the environmental conditions for optimum plant growth (1,2,7,10). Comparatively little information is available on the identification and biology of diseases affecting alstroemeria (5,9). In Canada, Chang *et al.* (3,4) reported that an alstroemeria root rot disease complex was caused by three pathogenic fungi: *Fusarium oxysporum* (Schlecht.) Snyd. and Hans., *R. solani* Kuhn, and *Pythium* spp. These three pathogens have been isolated from an individual stem or rhizome indicating their ability to coexist during infection. The above-ground symptoms of diseased plants include dark and necrotic stripes along leaf margins (Fig. 4) and pale green or chlorotic leaves (Fig. 2). A brown discoloration often occurs on the basal stem, rhizomes, and both the fibrous and storage roots. Severely infected rhizomes may have discolored vascular bundles and brown necrotic lesions (Fig. 3). Uninfected storage tubers are usually white, while infected tubers have small to large brown lesions (Fig. *5).* Plants infected with this disease may produce small abnormal flowers. In a greenhouse near Edmonton, alstroemeria flower production by several cultivars declined dramatically when the disease complex became widespread (Elaine Horner, personal communication).

An important prerequisite for developing an integrated management strategy for control of the disease complex in alstroemeria is to determine the incidence and severity of the complex in different commercial greenhouses, and to determine whether varietal differences exist in susceptibility to the disease. The objectives of this study were to determine the incidence and severity of alstroemeria root rot complex on cultivars grown in Alberta greenhouses and the isolation frequency, singly or in combination, of the three main pathogens involved in the disease complex.

Materials and methods

In June 1990, plant samples of 15 cultivars of *Alstroemeria* spp. were collected from seven greenhouses in southern and central Alberta. Stems were selected or removed from

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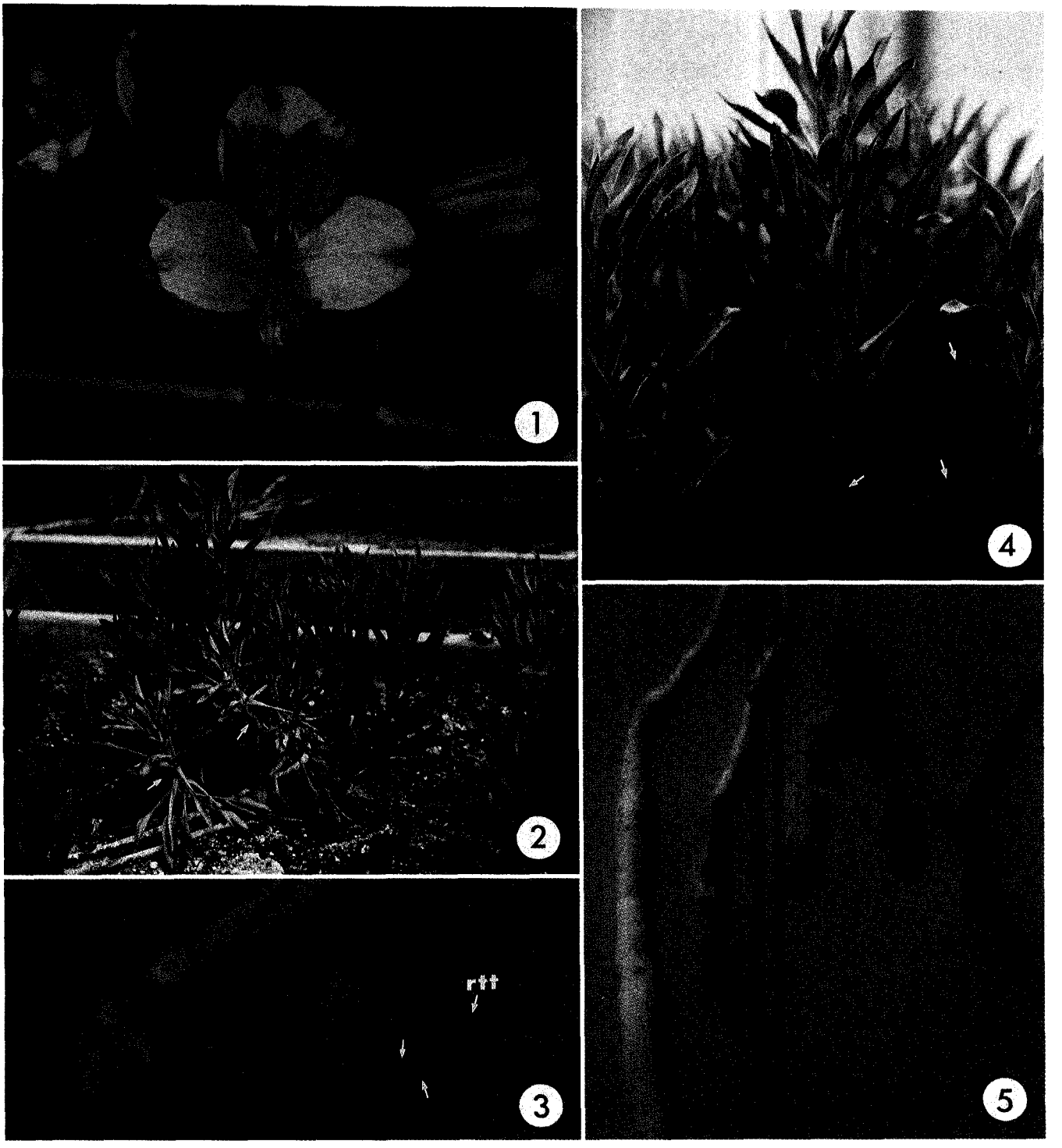

Fig. 1. A showy flower of alstroemeria.
Fig. 2. Infected plants growing in a soilless mix medium showing yellowing and dying stems (arrows).
Fig. 3. The most common symptoms on rhizomes are discoloration of vascular bundles (arrows) and rotted terminal tissues (rtt).
Fig. 4. Diseased plants showing symptoms of necrosis and discoloration along the leaf margin (arrows).
Fig. 5. Symptoms on the storage tubers; left healthy tuber and from left to right tubers with increasingly severe symptoms.

the one-meter-wide growing beds and the lower portions of the stems were examined for infection. The disease severity (DS) on these stems was based on a scale of 0 to S_4 where 0 = healthy, S_1 = 1-25%, S_2 = 26-50%, S_3 = 51-75%, and S_4 = 76-100% of the underground portion of the stem infected, respectively (4). The mean DS for the symptoms were calculated according to the following equation: $DS = [(S_1x1) + (S_2x2) + (S_3x3) + (S_4x4)]x100/Tx4$ where S_{1-4} = number of diseased plants in each category, and T = total number of stems examined, including healthy ones. The mean disease incidence (DI) was determined by dividing the number of infected stems by the total number of stems examined.

Fungal pathogens were isolated from the underground stems and rhizomes. Pieces of these organs, 5 mm long, were immersed in 1% sodium hypochlorite for 2 min, rinsed three times in sterilized distilled water and transferred onto potato dextrose agar (PDA) (Difco Inc.) in petri plates. The plates were incubated in darkness at 20°C for six days. Hyphal tips growing out from the tissue were excised and transferred onto PDA slants for further growth and identification.

The isolation rate of various combinations of *Fusarium* spp., *Pythium* spp., and *R. solani* from diseased tissues of rhizomes and basal stems were recorded for each cultivar. The DI and DS values were transformed using arcsine transformation, pooled according to different flowering types and examined statistically by an analysis of variance. Significance among the means was calculated with Duncan's multiple range test (12).

Results and discussion

Disease incidence and severity of the root rot disease complex of alstroemeria varied considerably among greenhouses and cultivars. Among the seven greenhouses surveyed the average disease incidence varied from 0 to 60.3% with a mean of 36.1%, while average disease severity ranged from 0 to 53% with a mean of 27% (Table 1). Among cultivars, the highest DI occurred on Orange Monarch (67.9%) while the DS was greatest on Saxony (47%) (Table 2). Both the lowest DI and DS values occurred on Paloma (16.6% and 11%, respectively). There was a weak correlation between DS and DI (R^2 = 0.31) at the time of the survey. Although there was uneven representation of cultivars in the four flower types among the greenhouses, plants with butterfly-type flowers had significantly higher DS and DI means than the plants with orchid-type flowers (Table 2). The mean DS and DI values for the butterfly, carmen and in-between types were not significantly different. There was a tendendcy for cultivars with flower colors other than pink to be more disease resistant than those with pink flowers (Table 2). Nevertheless, further studies using controlled inoculum levels and environmental conditions are needed to confirm this observation.

The isolation frequencies of pathogens from underground basal stems were quite different among greenhouses (Table 3). The most commonly isolated fungal pathogens in all seven greenhouses were *Fusarium* spp. In addition, frequent isolations of *Pythium* spp. occurred in greenhouses 3 and 5, and *R. solani* in greenhouses 4 and 6. The other four microorganisms and unknown ones isolated from alstroemeria (Table 3) were determined as nonpathogenic in a previous study (4).

Rhizomes and storage roots were embedded in growing media and were not easily removed, therefore, samples were taken only from greenhouse 7. *Fusarium* spp. were the major colonizing pathogens in rhizomes (85.7%) followed by *R. solani* (29.5%), and *Pythium* spp. (13.4%) (Table 4). Synchronous isolations of pathogens from rhizomes and basal stems are reported in Table 5. *Fusarium* spp. and *R. solani* were most frequently simultaneously isolated while *Fusarium* + *Pythium* was the next most common combination. This is not surprising because under natural conditions the highest infection rate of alstroemeria by a single pathogen was caused by *Fusarium* spp. (Tables 3 and 4). Likewise, the low isolation rate of each of *Pythium* spp. and *R. solani* from basal stems and rhizomes resulted in a low frequency of the combinations of *Pythium* + *Rhizoctonia* and *Pythium* + *Rhizoctonia* + *Fusarium.* Further study is needed to clarify whether synergistic or antagonistic effects occur among these pathogens on their host plants.

Flowers of alstroemeria can be harvested either by pulling or cutting the flowering stems, depending upon soil type, age of the plant, and cultivar (11). The wound caused by pulling the stem is an important site for penetration of pathogens into the rhizome (4). Since plants with butterfly-type flowers are more susceptible to the disease than those of the orchid-type, this suggests that harvesting by pulling stems of plants with butterfly-type flowers should be avoided when a greenhouse is contaminated with root-rot disease.

Unlike the other greenhouses, the growing medium of alstroemeria used in greenhouse 3 at Red Cliff was a soilless mix. It contained peat moss and vermiculite (1:1, v/v) which was steam sterilized prior to crop establishment. Using clean medium apparently was one of the important reasons for not finding the disease complex in the greenhouse.

Use of root-rot resistant cultivars has been an effective method for managing infection by organisms that incite soil-borne diseases (13). Low DS associated with high DI in the

cultivars Stripe Bird and Orange Monarch suggests that these cultivars may possess a certain degree of resistance. Paloma and Rio are tolerant to the pathogens investigated. These cultivars therefore are potentially useful as breeding material for developing resistant plants. However, chemical control of the disease should also be employed for susceptible cultivars with preferable flower colors. Since different pathogens are involved in the disease complex, the simultaneous application of a combination of fungicides should also be considered in an integrated management strategy. Until the most effective methods for controlling the disease complex have been elucidated, the prevalence and severity of the disease will likely continue to increase and may become a limiting factor in the floral production of alstroemeria.

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Table 1. Average incidence and severity of root rot disease complex of alstroemeria in seven Alberta greenhouses.

Number	Greenhouse Location	Incidence (%)[a]		Severity index (%)[ab]	
		Mean	Range	Mean	Range
3	Red Cliff	0	0	0	0
5	Lethbridge	18.5	0 - 57.1	23	0 - 39
6	Blackfalds	60.3	16.7 - 76.3	27	8 - 48
2	Red Cliff	48.6	20.6 - 90.4	28	11 - 67
7	Edmonton	45.1	7.50 - 73.2	30	15 - 46
1	Forestburg	45.5	7.50 - 64.0	30	3 - 54
4	Lethbridge	35.0	1.30 - 68.0	53	34 - 71
	Mean	36.1	27		

a Based on the average from cultivars planted in the greenhouse.

b Based on a scale of 0 - 4 where 0 = healthy, 1 = 1 - 25%, 2 = 26 - 50%, 3 = 51 - 75%, 4 = 76 - 100% of the underground portion of the stem infected.

Table 2. Average incidence and severity of root rot disease complex on 15 cultivars of alstroemeria grown in greenhouses of Alberta.

Cultivar	Flower type[1]	Flower colour	Disease* incidence (%)	Disease* severity index (%)[2]
Paloma	O	White	16.6	11
Rio	O	Yellow	29.7	26
group means			23.2 b	18.5 b
Striped Bird	I	Pale pink	40.0	18
Samora	I	Salmon pink	26.9	22
Westland	I	Purplish pink	54.0	31
Verloni	I	Pale pink	46.0	34
Othello		Purplish pink	58.5	37
group means			45.1 ab	28.4 ab
Red Bird	C	Dark red	39.9	19
Orange Monarch	C	Orange	67.9	22
Vanitas	C	Light pink	22.2	34
group means			43.3 ab	25.0 ab
Onasis	B	Dark pink	36.0	25
Jacqueline	B	Pink	48.6	32
Saffier	B	Purplish pink	56.0	40
Ontario	B	Dark pink	48.2	42
Saxony	B	Purplish pink	64.0	47
group means			50.6 a	37.2 a

1 Flower type:
O = Orchid-type (Plants produce tall, vigorous stems); B = Butterfly-type (Plants are shorter than 1.5 m and bloom later); I = In-between-type (Between the O and B types; produces flowers all year round); C = Carmen-type (Plants produce medium tall stems with a wide selection in colors)

2 Based on a scale of 0 - 4, where 0 = healthy, 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100% of the underground portion of the stem infected, respectively.

* Arcsin transformation used for analysis; untransformed means presented in table. Means followed by the same letter within a column are not significantly different at the 5% level according to Duncan's multiple range test.

Table 3. Average percent recovery of the microorganisms from discoloured underground stems of 15 cultivars of alstroemeria grown in greenhouses of Alberta.

Microorganism	Greenhouse							Average
	1	2	3	4	5	6	7	
Fusarium spp.	40.3	41.6	38.5	41.1	33.3	35.9	43.4	39.2
Rhizopus spp.	28.7	21.6	0	1.9	8.3	9.7	23.2	13.3
Penicillium spp.	7.9	8.5	38.5	9.3	8.3	1.0	17.2	13.0
Pythium spp.	6.4	6.4	15.3	9.3	33.4	3.9	0.8	10.8
Rhizoctonia solani	5.9	4.6	7.7	14.1	8.4	17.5	5.7	9.1
Bacteria	9.6	12.8	0	15.9	8.3	8.7	6.3	8.8
Botrytis spp.	0	0	0	6.5	0	2.9	1.1	1.5
Others (unkwown)	1.2	4.5	0	1.9	0	20.4	2.3	4.3

Table 4. Recovery (%) of the microorganisms from diseased rhizomes of alstroemeria cultivars.

Microorganism	Cultivar					Average
	Othello	Jacqueline	Rio	Ontario	Samora	
Fusarium spp.	68.2	83.9	85.7	100	90.9	85.7
Rhizoctonia solani	13.5	36.3	40.0	21.2	36.4	29.5
Penicillium spp.	12.0	29.8	17.1	6.1	3.0	13.6
Pythium spp.	29.2	4.8	8.6	0	24.2	13.4
Bacteria	9.9	16.1	14.3	9.1	12.1	12.3
Rhizopus spp.	16.9	6.5	0	0	3.0	5.3
Others	5.7	7.3	0	0	0	2.6

Data from greenhouse 7 only.

Table 5. Recovery (%) of the combination of *Fusarium* spp., *Rhizoctonia solani* and *Pythium* spp. from diseased basal stems and rhizomes of alstroemeria cultivars.

Cultivar	No. plants sampled	% isolation[x]			
		F + R	F + P	P + R	P + R + F
basal stem[y]					
Jacqueline	283	18.0	8.5	1.8	1.8
Ontario	78	11.5	2.6	0	0
Orange Monarch	24	4.1	12.5	0	0
Othello	188	6.9	3.2	0	0
Paloma	15	13.3	13.3	0	0
Red Bird	45	20.0	17.8	2.2	2.2
Rio	25	24.0	4.0	0	0
Saffier	29	3.4	6.9	0	0
Samora	40	17.5	0.0	0	0
Saxony	33	33.3	9.1	0	0
Striped Bird	42	2.3	11.9	0	0
Vanitas	76	9.0	6.4	0	0
Verloni	20	5.0	10.0	5.0	5.0
Victoria	9	33.3	0.0	0	0
Westland	33	15.2	3.0	3.0	3.0
group means		**14.5**	**7.3**	**0.8**	**0.8**
rhizome[z]					
Jacqueline	124	31.5	2.4	2.4	2.4
Ontario	33	21.2	0	0	0
Othello	192	8.9	8.3	2.6	0
Rio	35	28.6	5.7	5.7	2.8
Samora	33	33.3	18.2	3.0	3.0
group means		**24.7**	**6.9**	**2.7**	**1.6**

[x] F = *Fusarium* spp.; R = *Rhizoctonia solani;* P = *Pythium* spp.
[y] data were averaged from the samples of all greenhouses.
[z] data were obtained from greenhouse 7 only.