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from May until August. Red maple trees that had been stressed by root-pruning, transplanting, wounding, or defoliation were generally more attractive to flatheaded apple tree borer and other flatheaded borers than were non-stressed trees.

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Inheritance of Resistance to Fire Blight in *Malus* Crosses[1]

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Abstract

In eight interspecific and intraspecific *Malus* crosses, segregation of seedlings after greenhouse inoculation with *Erwinia amylovora* indicated that resistance to fire blight was polygenically controlled. In certain interspecific and intraspecific crosses, high percentages of resistant seedlings were recovered suggesting that sources of fire flight resistance are available in the cultivated apple as well as in other small-fruited *Malus* species.

Index words: apple, crabapple, *Erwinia amylovora*, interspecific hybridization

Introduction

Fire blight, a serious disease of *Malus* species, is widely distributed in the United States and is spreading to other parts of the world. Fire blight is caused by the bacterial organism *Erwinia amylovora* (Burr.) Winslow et al.

The significance of understanding the genetic control and inheritance of this disease is due to the fact that its control by using chemical sprays and cultural practices is difficult. Therefore, breeding for resistance to fire blight has become an essential objective. Gardner et al. (2) reported that resistance to fire blight is polygenically controlled and also presented evidence that resistance in *Malus* X*sublobata* PI 286613 (613) and *M.* X*robusta* No. 5 (R5) was conditioned by few dominant genes with additive effects. Korban et al. (3) also found that resistance to fire blight, in crosses among various genotypes of the cultivated apple (*Malus* X*domesitca* Borkh.), was polygenic with additive gene effects.

In this study, we report the genetic control and inheritance of fire blight resistance in both interspecific and intraspecific crosses of *Malus*.

Materials and Methods

To prepare the inoculum, cells of *E. amylovora* strain Ea 273 (provided by H.S. Aldwinckle, New York Agricultural Experiment Station, Geneva) were transfered to 15 ml of Modified Emerson's medium (MEM) (4) consisting of glucose (1 g/l), sodium chloride (2.5 g/l), yeast extract (1 g/l), and nutrient broth (8 g/l). Cells were incubated at 25°C (77°F) in a shaker bath at 90–110 osc/min. After 24 hr, cultures were at mid-log phase and cells were streaked onto MEM agar plates. These were incubated at 30°C (86°F) for an additional 24 hr and then cells were gently washed from the agar surface with sterile distilled water and suspended to a concentration of 4×10^7 cells/ml and used for inoculation.

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Controlled crosses among 10 *Malus* genotypes were conducted in the field both in 1984 and 1985. Seeds were extracted, stratified, and allowed to germinate in the greenhouse in flats containing a mixture of vermiculite and peat. Seedlings were transplanted to flats containing media made of equal parts of peat, vermiculite, sand, and soil and grown in the greenhouse.

When seedlings were 25 cm (10 in) tall, shoot tips were injected with a bacterial suspension of *E. amylovora* strain Ea 273 using a 26 gauge hypodermic needle until the cavity of the hole was overflowing with excess inoculum. Six weeks post-inoculation when necrotic lesions had stopped spreading, the total length of shoot and necrotic length of shoot were measured. Seedlings were then cut back at least 5 cm (2 in) below the infected lesion and allowed to regrow into single shoots. These were re-inoculated with an *E. amylovora* strain Ea 273 bacterial suspension. Identical measurements were taken six weeks following inoculation.

Lesion length calculated as a percent of current season's growth was averaged over both sets of inoculations. A distribution table for different classes of lesion length was then constructed.

Results and Discussion

Segregation of seedlings for susceptibility to fire blight was continuously distributed in different lesion classes in all eight progenies tested (Table 1) suggesting that resistance to fire blight is quantitatively controlled. This is similar to earlier findings (2, 3). In crosses of 'Priscilla' with *M. prunifolia* var. *microcarpa, M. prunifolia* var. *xanthocarpa*, and *M. floribunda* no.821, 65%, 39%, and 22% resistant seedlings were recovered, respectively. In an earlier study (3), we reported that 'Priscilla' was intermediately resistant to *E. amylovora* strain Ea 273, but it was a good parent for transmitting fire blight resistance in a number of crosses involving *M.* X*domestica* genotypes.

In this study, 'Priscilla' again proved to be a good parent especially when combined with *M. prunifolia* varieties *microcarpa* and *xanthocarpa*. Although, we don't have information on *M. prunifolia* var. *microcarpa* resistance to strain Ea 273, Gardner et al. (1) reported that *M. prunifolia* var. *xanthocarpa* was highly resistant to this strain in both greenhouse and nursery inoculations, and therefore is a good source for transmitting resistance as demonstrated in our study.

In crosses PWR35T69 X Delicious and PWR35T69 X HCR19T139, 53% and 44% of the seedlings were resistant, respectively. Selection PWR35T69 has been reported to have high field resistance to fire blight (D.F. Dayton, personal communication). Therefore, it is very likely that this selection is the one transmitting resistance to the progeny, and therefore it is a good parent for incorporating fire blight resistance in apple breeding programs. It is an advantage in an apple breeding program to use genotypes that have both resistance to fire blight and advanced horticultural characteristics including fruit size and quality.

Our screening technique and the resulting susceptibility ratings are based on inoculation and infection of current season's shoot growth, and therefore does not reflect susceptibility of older wood. Gardner et. al. (1) have found that ratings of *Malus* clones based on controlled inoculation of single shoots may or may not correspond with susceptibility of these clones to fire blight under field conditions. However, in a fire blight resistance breeding program, we need to screen seedlings under severe controlled conditions to recover those seedlings that are highly resistant. First year's growth of young seedlings is very critical for their survival and therefore our needle inoculation technique and our subsequent ratings are weeding out those genotypes that are potentially susceptible under field conditions highly favorable for disease spread.

Significance to the Nursery Industry

Identifying sources of fire blight resistance and determining the inheritance of this disease in *Malus* are essential for establishing effective breeding strategies to incorporate fire blight resistance into apple cultivars. We report here on an advanced apple selection and an apple cultivar that can transmit fire blight resistance to a high percentage of their progeny in certain crosses. This will be useful in breeding a fire blight resistant apple.

Table 1. Reaction of apple seedlings resulting from controlled crosses after greenhouse inoculation with *Erwinia amylovora* strain Ea 273.

Cross[z]	Total no. of plants	Distribution of plants in lesion-length classes[y,x]					Percent resistant seedlings[w]
		0–10%	11–30%	31–50%	51–90%	91–100%	
Priscilla x *M. baccata*	118	7	12	32	36	31	16
Priscilla x *M. floribunda* no. 821	168	14	23	30	42	59	22
Priscilla x *M. prunifolia* var. *microcarpa*	20	6	7	2	3	2	65
Priscilla x *M. prunifolia* var. *xanthocarpa*	49	9	10	6	6	18	39
Priscilla x M.A.4	6	0	1	1	4	0	17
PW R35 T69 X HC R19 T139	126	33	23	25	33	12	44
Delicious X PW R37 T133	15	1	2	3	2	7	20
PW R35 T69 X Delicious	365	46	148	87	68	16	53

[z]PW R35 T69, HC R19 T139, and PW R37 T133 are scab-resistant selections.

[y]Percent lesion length = [lesion length (cm) × 100]/current season's shoot length (cm). A reaction of 0–10% is highly resistant, 11–30% is resistant, 31–50% is intermediate, 51–90% is susceptible, and 91–100% is highly susceptible.

[x]Plants were inoculated twice and measurements on % lesion length were taken after each inoculation and the mean percent lesion length was calculated.

[w]This column combines seedlings in classes 0–10% and 11–30%.

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Growth Reduction of Eastern Redbud (*Cercis canadensis* L.) Seedlings Caused by Interaction with a Sorghum-Sudangrass Hybrid (Sudex)[1]

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Abstract

Growth of Eastern redbud (*Cercis canadensis L.*) seedlings was significantly reduced when co-cultivated with living sudex (*Sorghum bicolor (L.)* Moench x *Sorghum sudanese* (P.) Stapf. cv. FFR 201) and when sudex leaf material was incorporated into the growing medium. The reduction in redbud growth could not be reversed with increased fertilizer rates. Increasing the amount of fresh or dried sudex incorporated into the medium reduced redbud seedling growth in a linear manner. Sudex leaf material placed on the soil surface as a mulch had no effect on redbud growth.

Index Words: *Cercis*, sudex, allelopathy, competition, covercrop

Introduction

Nurseries use cover crops to control soil erosion and reduce weed populations during production. Between production cycles, cover crops are also used as a source of green manure for the improvement of soil structure and organic matter content (1). Sudex is commonly selected as a summer annual cover crop due to its rapid growth and ability to suppress weed growth (3).

However, both sorghum and related species have been shown to have possible allelopathic interactions with agronomic crops (2, 3, 5, 6). Root leachates from hydroponically-grown sudex were shown to be phytotoxic to both monocots and dicots in a seedling bioassay (2). Iyer *et al.* (4) demonstrated an inhibitory effect on the growth of pine seedlings with the incorporation of sudex into a container soil medium.

Since little information is available concerning the interaction of sudex with commonly grown nursery stock, this present study was initiated to evaluate the potential allelopathic effect of sudex on the growth of Eastern redbud.

Materials and Methods

Each experiment was conducted under greenhouse conditions in a completely randomized block design with or without factorial treatment combinations and treatments replicated 5 times. Temperatures were maintained at 23–27° day/20–24°C night (73–81/68–75°F). Supplemental lighting was provided by 1000 W high pressure sodium vapor lamps (Energy Technics, York, PA) during October through April 1986–87. Lamps provided a photosynthetic photon flux density of 500 $\mu mol \cdot s^{-1} \cdot m^{-2}$. The container medium used throughout these experiments was a non-pasteurized artificial medium (5 parts Promix BX: 1 part perlite by vol.). The containers were watered overhead as needed and fertilized with Peters 14-15-16 (14N-6.5P-13.3K) at 200 ppm nitrogen at each watering unless otherwise stated.

Redbud seed was pre-treated with H_2SO_4 for 30 minutes, rinsed and moist stratified at 5° C (41°F) for 60 days. In seedling experiments, 5 seeds were sown in each 1 gal. (#1) container. The seedlings were thinned to 3 plants per container 3 weeks after sowing. Redbud transplants were produced in a similar manner and uniform seedlings (15 cm in height) were set into the treated containers 6 weeks following sowing.

Sudex Treatment Experiment: Sudex was grown as described above, either in 1 gal. (#1) treatment containers or in 50 × 35 × 10 cm (20 × 14 × 4 in) plastic flats for biomass production. Sudex treatments included living sudex, sudex incorporated into the growth medium and a sudex surface mulch. Incorporated sudex treatments contained fresh leaf material cut into approximately 3 cm (1.2 in) pieces and mixed throughout the growing medium. For a living

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