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Evaluation of Selected Crabapple Cultivars for Insect Resistance[1]

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Abstract

Twenty-four cultivars of *Malus* spp. were evaluated for resistance to naturally occurring insect pests at replicated plantings in Detroit, Lansing, and Cadillac, Michigan. 'Adams,' 'Candied Apple,' and 'Sugar Tyme' crabapples were the most resistant to defoliation by gypsy moth, fall cankerworm, and eastern tent caterpillar. 'Sugar Tyme,' in particular, was almost untouched by gypsy moth or fall cankerworm (less than 1.3% defoliation). These data must be interpreted cautiously, because previous research has shown that gypsy moth larvae are attracted to the largest Malus trees in a planting, regardless of cultivar.

Two cultivars, 'Robinson' and 'Red Jewel,' were highly resistant to rose chafer and apple-and-thorn skeletonizer damage. The fact that neither of these were particularly resistant to gypsy moth or cankerworm suggests a different mechanism of resistance for defoliators and skeletonizers.

Index words: *Malus*, gypsy moth, fall cankerworm, apple-and-thorn skeletonizer, rose chafer, apple scab.

Significance to the Nursery Industry

Increasing adoption of an integrated pest management (IPM) approach to maintaining landscape plant material, and the accompanying desire to use less pesticides, has resulted in an increase in demand for insect and disease resistant trees and shrubs. The 24 cultivars of *Malus* evaluated in this study varied considerably in their level of resistance to six insect pests and two diseases. Overall, the lowest levels of insect infestation and damage were found on *Malus* 'Sugar Tyme,' 'Adams,' 'Red Splendor,' 'Velvet Pillar' and 'Red Jewel.' Of particular interest is the high level of resistance exhibited by 'Sugar Tyme' to four lepidopteran pests. The ranking of these 24 cultivars should be useful to plant breeders attempting to incorporate insect and disease resistance into new *Malus* lines.

Introduction

Traditionally, *Malus* cultivars are selected for landscape plantings on the basis of fruit color, foliage color, height, winter hardiness, and disease resistance (3,4,8,13,16). Little attention has been paid to insect resistance, yet it is one of the most important factors influencing the vitality and longevity of trees. Severe losses due to outbreaks of insect pests have led to incorporating insect resistance as an integral part of breeding many agricultural crops (9,12). Research on insect pests of trees and shrubs lags far behind that for field, fruit and vegetable crops, probably because the value of field crops was once far greater than that of nursery crops. However, in many states, nursery sales now exceed fruit and vegetable crop sales. The high value of nursery trees and shrubs, and the low tolerance for insect infestation when shipping plants across state lines has led to a heavy reliance on chemical control of insect pests (2). Recent changes in worker-protection laws and concern about pesticides leaching into groundwater have forced nursery growers to re-examine pest management strategies. In some cases, IPM programs have replaced routine insecticide sprays. Where IPM programs have been implemented in landscaping businesses or nurseries, the quantity of pesticide used has typically been reduced by more than 70% (15). The growing pressure for nurseries and landscapers to be more judicious with pesticides has created a demand for more information on the resistance of landscape trees to insects.

Little information is available on the relative resistance levels of landscape trees to insects. In forest and woodlot-oriented investigations, *Malus* spp. are listed as a preferred host for the gypsy moth, *Lymantria dispar* L. (5,10). In a shade tree study, three cultivars of crabapple, 'Red Silver,' 'Radiant,' and 'Pink Perfection,' were among the five most susceptible trees to gypsy moth defoliation among the 21 tree types evaluated (14). The fall cankerworm, *Alsophila pometaria* (Harris), the rose chafer, *Macrodactylus subspinosus* (Fabricius), and the eastern tent caterpillar, *Malacasoma americanum* (Fabricius), have also been reported to occasionally defoliate crabapple (7,11). However, no information was found on the susceptibility of crabapple trees (*Malus* spp.) to these insects, other than an occasional reference to *Malus* spp. being one of their preferred hosts (1,6,7,11).

In an attempt to determine the variability of insect resistance levels among selected cultivars of flowering crabapples, we collected data on naturally occurring pests at three trial evaluation sites in Michigan.

Materials and Methods

The research trials were established in 1986–87 at three Michigan sites on the basis of location, accessibility, on-site maintenance equipment and the availability for long-term use. The sites were diverse in their climatic and soil characteristics: Maple Hill Cemetery, Cadillac, in USDA hardiness zone 4a provided trees with sandy soil at 6.8 pH; Detroit City Nursery, Detroit, in USDA hardiness zone 6a provided trees with clay soil at 6.8 pH, and Michigan State University

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Horticulture Teaching and Research Center, Lansing, in USDA hardiness zone 5b provided trees with sandy loam soil at 6.4 pH.

All trees were handled bareroot and planted in a square design at a 4.5 × 4.5 m (15 × 15 ft) spacing. Size of stock at planting varied between cultivars, but the size of the trees within each cultivar was uniform. Each plant was handled for the trials as it would be in commercial practice. Six plants of each cultivar were randomly assigned positions within plots. Cultivars were selected on the basis of their potential use in the landscape, availability in the trade and the likelihood for environmental tolerance as well as insect and disease resistance.

Plot maintenance practices varied slightly between locations. The Lansing plot had grass aisles and herbicides were applied twice annually within rows. The Cadillac plot was maintained in grass with mulch applied around individual trees and herbicides applied under individual trees, as needed. The Detroit plot was maintained by cross-cultivation with weed control applied under individual trees, as needed. All plots received fall and spring applications of 16-16-16 (N-P-K) at a rate of 200 g (8 oz) per tree. Pruning was limited to the removal of dead or damaged branches and sucker growth.

Crabapple trees at the Detroit, Lansing, and Cadillac, Michigan trial sites were observed for insect activity in 1990 and 1991. Insects causing obvious injury were: gypsy moth, *Lymantria dispar* (Linnaeus), fall cankerworm, *Alsophila pometaria* (Harris), apple-and-thorn skeletonizer, *Choreutis pariana* (Clerck), eastern tent caterpillar, *Malacasoma americanum* (Fabricius), rose chafer, *Macrodactylus subspinosus* (Fabricius), and apple aphid, *Aphis pomi* DeGeer. In addition, data were collected on the incidence of apple scab and fireblight at the Lansing site in 1991. All insect infestations were natural. No insecticides were used at the trial sites.

Lansing site. Apple-and-thorn skeletonizer damage was recorded for each tree at the Lansing site on July 24, 1991, by estimating the proportion of brown, skeletonized leaves. Defoliation estimates were made after a training session where estimates were compared among observers. The reliability of this method was described by Peterson and Smitley (14). An outbreak of fall cankerworm in central Michigan provided an opportunity to observe damage to crabapple trees. Cankerworm feeding damage peaked the first week in June. We estimated percent defoliation of each tree on June 10, 1991. The only other defoliation damage at that time was by eastern tent caterpillar. Tent caterpillar damage was restricted to a small number of crabapple trees, and could be separated from the cankerworm damage by excluding the branches surrounding the tent from the cankerworm defoliation estimate. Apple aphid infestations were quantified on trees at the Lansing site on August 5, 1991, by examining four terminals on the north, south, east, and west side of each tree, for a total of 16 terminals examined on each tree. Data were collected as the number of infested terminals per tree. If any aphids were found in a quick examination of the terminal (the last 25 cm (10 in) of stem and leaves), it was counted as being infested. Apple scab infection levels were determined by randomly collecting 10 leaves from each of the four cardinal compass sides of each tree. A total of 40 leaves per tree were then examined for scab lesions. A leaf was recorded as infected if one or more lesions were found. Fireblight strikes were observed on September 25, 1992. Data were recorded as the proportion of terminals with cankers and necrotic leaves.

Cadillac site. Test trees at the Cadillac site were separated from the nearest woodlot by at least 100 m. No gypsy moth egg masses were found in the planting. Larvae were apparently blown into the trial area. On June 19, 1991, each crabapple tree was observed for 60 seconds to determine the number of gypsy moth larvae present. Rose chafer skeletonizing damage was estimated in the same way as described for apple-and-thorn skeletonizer damage. The proportion of foliage on each tree damaged by rose chafer was estimated on July 24, 1991, at the Lansing site.

Detroit site. Malus trees at the Detroit site were observed for tents and eastern tent caterpillars on June 3, 1991. Data were recorded as the number of colonies per tree.

Results and Discussion

Gypsy moth. The number of gypsy moth larvae found on crabapple cultivars varied from 0.7 per tree for 'Sugar Tyme' to 7.0 per tree for 'Harvest Gold' (Table 1). All cultivars with a mean of less than 2.5 per tree supported less gypsy moth larvae than the two most heavily infested cultivars 'Professor Sprenger' and 'Harvest Gold' (Tables 1 and 2). Although cultivars differed in the number of gypsy moth larvae that were found on them, we must be cautious in interpreting this information. Recently, the number of gypsy moth larvae per tree was found to be correlated with tree size (17). We do not know how much of the difference in larval densities among cultivars in our test was due to variation in tree size, or other factors. Crabapple is one of the most susceptible trees to gypsy moth defoliation (14). Yet prior to this study no information was available on relative susceptibility among cultivars. The broad differences among the 24 cultivars in this study suggest a need for further evaluation of crabapples. If the resistance exhibited by some cultivars in this study is observed again in similar evaluations, the cultivars could be recommended for planting in areas where gypsy moth infestations are expected.

Fall cankerworm. Defoliation of crabapple cultivars from cankerworm feeding ranged from 1.3% on 'Sugar Tyme' to 12.2% on *yunnanensis* 'Veitchii' (Tables 1 and 2). The level of defoliation among replicate trees within any cultivar treatment was consistent, suggesting that cankerworm larvae have definite preferences for some cultivars over others. 'Sugar Tyme,' 'Red Splendor,' 'Professor Sprenger,' 'Madonna,' 'Candied Apple,' and 'Velvet Pillar' were the least preferred, with less than 2.5% defoliation. *Yunnanensis* 'Veitchii,' 'White Candle,' 'Red Baron,' 'Baskatong,' and 'Brandywine' were the most heavily infested, with more than 6.5% defoliation.

Eastern tent caterpillar. Infestation levels of eastern tent caterpillar were lower than that for gypsy moth and cankerworm. Even so, enough colonies were present to indicate some preference of eastern tent caterpillars for a few cultivars. 'Professor Sprenger,' 'Henningi,' and 'Centurion' were preferred over 'Red Baron' and all the other cultivars for which no colonies were found (Table 2).

Apple-and-thorn skeletonizer. Defoliation caused by the apple-and-thorn skeletonizer ranged from 0.0% for 'Red

Table 1. Insect numbers or percent defoliation ± SD for crabapple cultivars listed in alphabetical order.

Malus cultivar	Gypsy moth 1991 n	Gypsy moth 1991 Larvae per tree	Gypsy moth 1992 n	Gypsy moth 1992 Larvae per tree	Fall cankerworm n	Fall cankerworm % defoliation	Fall cankerworm Transformed data	Eastern tent caterpillar n	Eastern tent caterpillar Colonies per tree	Apple-and-thorn skeletonizer n	Apple-and-thorn skeletonizer % defoliation	Apple-and-thorn skeletonizer Transformed data
Adams	6	1.0 ± 2.0	6	3.7 ± 4.0	6	2.8 ± 1.8	9.4 ± 3.0	6	0 ± 0	6	9.7	17.1 ± 7.3
Baskatong	6	0.7 ± 0.8	6	0.5 ± 0.8	6	7.0 ± 3.3	15.1 ± 3.7	6	0 ± 0	6	11.5	18.8 ± 7.9
Brandywine	7	1.6 ± 1.7	5	1.0 ± 2.2	5	6.8 ± 2.8	14.9 ± 3.4	5	0.29 ± 0.49	5	6.8	14.9 ± 3.3
Candied Apple	6	1.2 ± 1.0	5	1.2 ± 1.1	6	2.2 ± 0.8	8.4 ± 1.6	6	0 ± 0	6	26.2	29.5 ± 11.6
Centurion	6	1.5 ± 1.0	5	1.8 ± 1.1	6	3.2 ± 0.4	10.3 ± 0.6	6	0.33 ± 0.52	6	6.7	14.9 ± 2.3
Harvest Gold	4	7.0 ± 7.3	3	3.3 ± 2.1	6	4.2 ± 2.8	11.1 ± 4.5	6	0 ± 0	6	9.7	16.5 ± 9.9
Henningi	3	1.3 ± 1.5	2	0.0 ± 0.0	6	4.3 ± 2.2	11.8 ± 3.0	6	0.33 ± 0.58	6	6.7	14.4 ± 4.9
Henry Kohankie	5	1.2 ± 1.6	4	1.0 ± 0.8	6	5.3 ± 1.6	13.3 ± 2.1	7	0.20 ± 0.45	6	10.5	18.3 ± 6.2
Indian Magic	5	1.6 ± 2.6	5	0.6 ± 0.9	7	3.3 ± 1.8	10.3 ± 2.7	4	0 ± 0	7	3.0	8.2 ± 7.1
Madonna	6	2.7 ± 3.4	5	0.0 ± 0.0	4	2.0 ± 0.8	8.0 ± 1.7	6	0 ± 0	4	3.8	10.7 ± 4.0
Pink Spires	4	1.8 ± 2.2	4	0.3 ± 0.5	6	3.2 ± 3.1	9.3 ± 4.8	6	0 ± 0	6	4.8	12.0 ± 4.9
Professor Sprenger	4	5.8 ± 4.6	4	2.3 ± 2.9	6	1.8 ± 1.2	7.5 ± 2.3	6	0.75 ± 0.5	6	5.8	13.1 ± 5.6
Red Baron	6	2.3 ± 2.3	6	1.2 ± 1.7	6	8.0 ± 7.4	15.2 ± 7.5	6	0.17 ± 0.41	6	4.2	11.6 ± 2.5
Red Jewel	6	3.7 ± 2.6	6	1.2 ± 1.0	6	3.2 ± 1.8	9.8 ± 3.3	6	0 ± 0	6	0.0	0.0 ± 0.0
Red Silver	4	3.0 ± 2.5	3	0.0 ± 0.0	6	3.3 ± 1.9	10.2 ± 3.2	6	0 ± 0	6	25.3	28.4 ± 15.2
Red Splendor	5	1.6 ± 2.3	4	0.0 ± 0.0	6	1.5 ± 0.5	7.0 ± 1.3	6	0.22 ± 0.44	6	3.0	9.3 ± 4.1
Robinson	10	4.4 ± 3.2	8	0.9 ± 1.1	6	3.5 ± 1.0	10.7 ± 1.7	6	0 ± 0	6	2.0	7.1 ± 4.4
Spring Snow	6	3.8 ± 2.9	6	0.2 ± 0.4	6	4.3 ± 3.1	11.3 ± 4.6	6	0 ± 0	6	3.8	11.2 ± 2.2
Strawberry Parfait	5	3.4 ± 1.9	4	1.0 ± 0.8	6	3.3 ± 0.8	10.5 ± 1.4	6	0.20 ± 0.45	6	6.0	13.5 ± 5.1
Sugar Tyme	6	0.7 ± 1.2	6	1.0 ± 0.6	6	1.3 ± 0.5	6.6 ± 1.2	6	0 ± 0	6	1.5	7.0 ± 1.3
Velvet Pillar	4	2.3 ± 1.4	4	1.0 ± 1.2	6	2.2 ± 0.8	8.4 ± 1.6	6	0 ± 0	6	2.7	9.0 ± 3.3
White Candle	3	1.3 ± 1.5	2	0.0 ± 0.0	5	9.6 ± 4.2	17.8 ± 4.3	5	0 ± 0	5	11.4	18.9 ± 6.9
White Cascade	6	1.8 ± 1.2	6	2.7 ± 1.8	6	3.8 ± 1.8	11.1 ± 2.6	6	0 ± 0	6	7.7	15.6 ± 4.6
yunnanensis 'Veitchii'	6	4.8 ± 2.2	6	4.0 ± 1.7	6	12.2 ± 7.1	19.8 ± 6.4	6	0 ± 0	6	22.5	26.8 ± 13.2
LSD P = 0.05		3.1		3.0			4.0		0.31			8.1

Jewel' to 26.2% for 'Candied Apple' (Tables 1 and 2). The variation in defoliation among replicate trees within cultivar treatments was low, indicating that the skeletonizer has strong preferences for some cultivars over others. The most resistant cultivars, 'Red Jewel,' 'Sugar Tyme,' 'Robinson,' and 'Velvet Pillar,' averaged less than 3% defoliation. The most susceptible cultivars; *yunnanensis* 'Veitchii,' 'Red Silver,' and 'Candied Apple,' averaged more than 22% defoliation.

Rose chafer. Skeletonizing damage to crabapples varied from 0.8% on 'Red Jewel' to 60.0% on 'Candied Apple' (Tables 3 and 4). 'Red Jewel' was almost untouched by rose chafers, indicating a high level of resistance. 'Adams,' 'Madonna,' 'Sugar Tyme,' 'Robinson,' 'Pink Spires,' and

Table 2. Ranking of crabapple cultivars, from least infested to most infested, for gypsy moth, fall cankerworm, and eastern tent caterpillar.

Gypsy moth larvae per tree (average of 1991 and 1992)		Fall cankerworm % defoliation		Eastern tent caterpillar colonies per tree	
Baskatong	0.6	Sugar Tyme	1.3	Adams	0.0
Henningi	0.7	Red Splendor	1.5	Baskatong	0.0
White Candle	0.7	Professor Sprenger	1.8	Candied Apple	0.0
Red Splendor	0.8	Madonna	2.0	Harvest Gold	0.0
Sugar Tyme	0.9	Candied Apple	2.2	Indian Magic	0.0
Henry Kohankie	1.1	Velvet Pillar	2.2	Madonna	0.0
Indian Magic	1.1	Adams	2.8	Pink Spires	0.0
Pink Spires	1.1	Centurion	3.2	Red Jewel	0.0
Candied Apple	1.2	Pink Spires	3.2	Red Silver	0.0
Brandywine	1.3	Red Jewel	3.2	Robinson	0.0
Madonna	1.4	Strawberry Parfait	3.3	Spring Snow	0.0
Red Silver	1.5	Red Silver	3.3	Sugar Tyme	0.0
Centurion	1.7	Indian Magic	3.3	Velvet Pillar	0.0
Velvet Pillar	1.7	Robinson	3.5	White Candle	0.0
Red Baron	1.8	White Cascade	3.8	White Cascade	0.0
Spring Snow	2.0	Harvest Gold	4.2	Red Baron	0.0
Strawberry Parfait	2.2	Henningi	4.3	*yunnanensis* 'Veitchii'	0.0
White Cascade	2.3	Spring Snow	4.3	Henry Kohankie	0.20
Adams	2.4	Henry Kohankie	5.3	Strawberry Parfait	0.20
Red Jewel	2.5	Brandywine	6.8	Red Splendor	0.22
Robinson	2.7	Baskatong	7.0	Brandywine	0.29
Professor Sprenger	4.1	Red Baron	8.0	Centurion	0.33
yunnanensis 'Veitchii'	4.4	White Candle	9.6	Henningi	0.33
Harvest Gold	5.2	*yunnanensis* 'Veitchii'	12.2	Professor Sprenger	0.75

Table 3. Insect numbers, percent defoliation, or infected foliage ± SD for crabapple cultivars listed in alphabetical order.

	Rose chafer			Apple aphid		Apple scab		Fireblight
Malus cultivar	n	% defoliation	Transformed data	n	Transformed data	n	Colonies per 16 terminals	n	% infected terminals
Adams	6	6.2	12.2 ± 8.6	6	1.0 ± 1.7	6	9.2 ± 7.5	6	0.0 ± 0.0
Baskatong	6	59.2	50.1 ± 20.2	6	4.8 ± 4.6	6	19.3 ± 13.0	6	0.0 ± 0.0
Brandywine	7	30.0	31.0 ± 20.7	5	0.0 ± 0.0	5	1.2 ± 2.7	5	0.0 ± 0.0
Candied Apple	6	60.0	49.5 ± 25.7	6	3.5 ± 4.6	6	30.1 ± 10.7	6	0.0 ± 0.0
Centurion	6	28.6	33.7 ± 19.5	6	2.2 ± 2.1	6	17.3 ± 8.1	6	0.0 ± 0.0
Harvest Gold	4	27.0	30.0 ± 16.1	6	1.3 ± 1.2	6	0.5 ± 1.2	4	5.0 ± 8.4
Henningi	3	14.3	21.6 ± 7.3	6	4.7 ± 5.0	6	11.5 ± 12.7	6	0.0 ± 0.0
Henry Kohankie	5	59.6	53.1 ± 26.7	6	1.3 ± 1.2	6	0.0 ± 0.0	6	0.0 ± 0.0
Indian Magic	5	37.0	36.2 ± 19.1	7	5.5 ± 4.6	7	31.4 ± 10.9	7	0.0 ± 0.0
Madonna	6	8.8	18.0 ± 4.4	4	2.3 ± 3.3	4	0.0 ± 0.1	4	7.9 ± 16.8
Pink Spires	4	13.8	20.8 ± 8.7	6	4.2 ± 2.7	6	10.2 ± 8.3	6	0.0 ± 0.0
Professor Sprenger	4	28.8	31.9 ± 8.9	6	1.3 ± 1.2	6	1.5 ± 3.7	6	0.0 ± 0.0
Red Baron	6	56.7	49.7 ± 16.0	6	0.4 ± 0.5	6	28.6 ± 7.0	6	0.0 ± 0.0
Red Jewel	6	0.8	3.6 ± 4.2	6	4.5 ± 2.7	6	0.0 ± 0.0	6	10.0 ± 20.0
Red Silver	4	42.5	40.2 ± 12.1	6	1.3 ± 1.8	6	35.2 ± 6.1	6	0.0 ± 0.0
Red Splendor	5	20.0	22.6 ± 18.8	6	1.3 ± 1.0	6	0.3 ± 0.8	6	0.0 ± 0.0
Robinson	10	11.9	16.9 ± 11.4	6	2.2 ± 3.9	6	33.5 ± 7.9	6	0.0 ± 0.0
Spring Snow	6	22.8	27.3 ± 11.3	6	1.0 ± 1.3	6	1.6 ± 3.1	6	0.0 ± 0.0
Strawberry Parfait	5	52.0	46.6 ± 20.7	6	4.8 ± 5.7	6	10.3 ± 10.3	6	0.0 ± 0.0
Sugar Tyme	6	9.2	15.6 ± 9.4	6	2.5 ± 0.8	6	0.5 ± 0.8	6	0.0 ± 0.0
Velvet Pillar	4	48.8	44.6 ± 21.4	6	0.2 ± 0.4	6	31.8 ± 6.8	6	0.0 ± 0.0
White Candle	3	50.0	45.0 ± 23.1	5	8.8 ± 4.7	5	23.6 ± 14.5	5	3.3 ± 6.1
White Cascade	6	50.8	45.4 ± 23.1	6	4.2 ± 5.7	6	5.7 ± 7.8	6	0.0 ± 0.0
yunnanensis 'Veitchii'	6	21.7	27.1 ± 7.8	6	0.0 ± 0.0	6	39.6 ± 0.9	6	4.2 ± 6.6
LSD P = 0.05			20.1		3.7		9.7		NS

'Henningi' were less than 15% defoliated by skeletonizer damage. 'Red Splendor,' *yunnanensis* 'Veitchii,' 'Spring Snow,' 'Harvest Gold,' 'Centurion,' and 'Professor Sprenger,' were less than 30% defoliated, indicating a moderate level of resistance to the rose chafer.

Apple aphid. Aphid activity on crabapple cultivars varied from 0 infested terminals on 'Brandywine' and *yunnanensis* 'Veitchii' to 8.8 on 'White Candle' out of a total of 16 terminals examined (Tables 3 and 4). 'Brandywine,' *yunnanensis* 'Veitchii,' 'Velvet Pillar,' and 'Red Baron' all had less than 0.5 terminals infested with apple aphids. All cultivars with less than 3.0 terminals infested showed at least a moderate level of resistance to apple aphids.

Apple scab and fireblight. Data were collected on apple scab and fireblight to allow for a quick determination of disease susceptibility while looking for cultivars that showed

Table 4. Ranking of crabapple cultivars from least infested to most infested for apple-and-thorn skeletonizer, rose chafer and apple aphid.

Apple-and-thorn skeletonizer: % defoliation		Rose chafer: % defoliation		Apple aphid: infested terminals	
Red Jewel	0.0	Red Jewel	0.8	Brandywine	0.0
Sugar Tyme	1.5	Adams	6.2	*yunnanensis* 'Veitchii'	0.0
Robinson	2.0	Madonna	8.8	Velvet Pillar	0.1
Velvet Pillar	2.7	Sugar Tyme	9.2	Red Baron	0.3
Red Splendor	3.0	Robinson	11.9	Adams	0.8
Indian Magic	3.0	Pink Spires	13.8	Spring Snow	0.9
Madonna	3.8	Henningi	14.3	Red Splendor	1.3
Spring Snow	3.8	Red Splendor	20.0	Henry Kohankie	1.3
Red Baron	4.2	*yunnanensis* 'Veitchii'	21.7	Professor Sprenger	1.3
Pink Spires	4.2	Spring Snow	22.8	Red Silver	1.3
Professor Sprenger	5.8	Harvest Gold	27.0	Harvest Gold	2.1
Strawberry Parfait	6.0	Centurion	28.6	Centurion	2.1
Henningi	6.7	Professor Sprenger	28.8	Robinson	2.1
Centurion	6.7	Brandywine	30.0	Madonna	2.2
Brandywine	6.8	Indian Magic	37.0	Sugar Tyme	2.5
White Cascade	7.7	Red Silver	42.5	Candied Apple	3.5
Harvest Gold	9.7	Velvet Pillar	48.8	White Cascade	4.1
Adams	9.7	White Candle	50.0	Pink Spires	4.1
Henry Kohankie	10.5	White Cascade	50.8	Red Jewel	4.5
White Candle	11.4	Strawberry Parfait	52.0	Henningi	4.6
Baskatong	11.5	Red Baron	56.7	Baskatong	4.8
yunnanensis 'Veitchii'	22.5	Baskatong	59.2	Strawberry Parfait	4.8
Red Silver	25.3	Henry Kohankie	59.6	Indian Magic	5.5
Candied Apple	26.2	Candied Apple	60.0	White Candle	8.8

Table 5. The relative ranking of crabapple cultivars from least infested (1) to most infested (24) for six insect pests observed in 1990 and 1991 average insect ranking is a mean of the six ranking figures.

Crabapple cultivar	Gypsy moth	Fall cankerworm	E. tent caterpillar	Apple-and-thorn skeletonizer	Apple aphid	Rose chafer	Average insect ranking
Sugar Tyme	5	1	9	2	15	4	6.0
Red Splendor	4	2	20	5	7	8	7.7
Madonna	11	4	9	7	14	3	8.0
Velvet Pillar	14	6	9	4	3	17	8.8
Red Jewel	20	10	9	1	19	1	9.8
Pink Spires	8	9	9	10	18	6	10.0
Adams	19	7	9	18	5	2	10.0
Robinson	21	14	9	3	13	5	10.8
Spring Snow	16	18	9	8	6	10	11.2
Indian Magic	7	13	9	6	23	15	12.2
Brandywine	10	20	21	15	1	14	13.5
Centurion	13	8	22	14	12	12	13.5
Red Silver	12	12	9	23	10	16	13.7
Professor Sprenger	22	3	24	11	9	13	13.7
Henningi	2	17	23	13	20	7	13.7
Candied Apple	9	5	9	24	16	24	14.5
Red Baron	15	22	17	9	4	21	14.7
Harvest Gold	24	16	9	17	11	11	14.7
yunnanensis 'Veitchii'	23	24	9	22	2	9	14.7
White Cascade	18	15	9	16	17	19	15.6
Henry Kohankie	6	19	19	19	8	23	15.7
Baskatong	1	21	9	21	21	22	15.8
White Candle	3	23	9	20	24	18	16.2
Strawberry Parfait	17	11	18	12	22	20	16.8

insect resistance. Apple scab infection varied from 0.0 leaves for 'Henry Kohankie,' 'Madonna,' and 'Red Jewel' to 39.6 for *yunnanensis* 'Veitchii,' of 40 leaves examined (Table 3). In addition to the cultivars just mentioned with no scab infection, 'Brandywine,' 'Harvest Gold,' 'Professor Sprenger,' 'Red Splendor,' 'Spring Snow' and 'Sugar Tyme' also had fewer than 5 leaves, of the 40 that were examined, infected with apple scab.

Only five cultivars, 'Red Jewel,' 'Madonna,' 'Harvest Gold,' *yunnanensis* 'Veitchii,' and 'White Candle,' were observed to have fireblight symptoms. Fireblight cankers were so infrequent that there were no differences among cultivars (Table 3).

When rankings were averaged for all insect pests, five cultivars, 'Sugar Tyme,' 'Red Splendor,' 'Madonna,' 'Velvet Pillar' and 'Red Jewel' had average rankings of less than 10 (Table 5). These cultivars were, overall, the most resistant to insect infestation.

Some similarities were found among cultivars in their resistance to the three lepidopteran defoliators (gypsy moth, fall cankerworm and eastern tent caterpillar), and to the two skeletonizers (apple-and-thorn skeletonizer and rose chafer). 'Adams,' 'Candied Apple,' and 'Sugar Tyme' all demonstrated excellent resistance to lepidopteran defoliators. In particular, 'Sugar Tyme' had almost no feeding injury (less than 1.3% defoliation) from gypsy moth or fall cankerworm (Table 2). Two cultivars, 'Robinson' and 'Red Jewel,' were highly resistant to skeletonizer damage (Table 4). Neither of these two cultivars was particularly resistant to gypsy moth or cankerworm, suggesting the possibility of a cuticle or epidermal-based resistance mechanism. Apparently scab resistance is determined differently, because 'Red Jewel' was resistant to apple scab, while 'Robinson' was susceptible.

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