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Evaluation of Ten Landscape Trees for the Midwest

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Abstract

Specific problems in plant selection for the midwest vary widely because of large differences in climate, soils, and urbanization. A project was started in 1984 to identify and evaluate worthy landscape plants for use in Kansas and other areas of the midwest. As of 1991, 40 species and cultivars have been planted in six locations throughout Kansas. Data collected for four years include survival, height, stem diameter, foliage quality, and overall quality. The results of the first two completed segments of this study (1984 and 1985) are presented.

Index words: Plant evaluation.

Species used in this study: Greenlace Norway maple (*Acer platanoides* 'Greenlace'); red maple (*Acer rubrum*); mountain mahogany (*Cercocarpus montanus*); thornless cockspur hawthorn (*Crataegus crus-galli* var. *inermis*); Kimberly European ash (*Fraxinus excelsior* 'Kimberly'); Chinese pistache (*Pistacia chinensis*); Amur corktree (*Phellodendron amurense*); Aristocrat callery pear (*Pyrus calleryana* 'Aristocrat'); sawtooth oak (*Quercus acutissima*); Shum and oak (*Quercus shumardii*).

Significance to the Nursery Industry

Evaluation of plants under relatively extreme environmental conditions provides valuable information to plant producers and users. Our continuing studies have identified some species and cultivars that have potential for increased use in the midwest and other areas of the country with similar environmental conditions. We have also identified species and cultivars that did not perform well for various reasons. These should be carefully considered for inclusion in the retail, contractual, or landscape palette for these regions.

Introduction

Evaluations of new, different, and superior plants are meaningful to nurserymen, arborists, landscape architects and designers, and consumers. Specific problems in plant selection for Kansas vary widely because of large differences in climate, soils, and urbanization (9).

Many programs have been developed for evaluation of woody landscape plants throughout the nation (5, 6, 7). Numerous species have been evaluated in the national NC-7 program. Unfortunately, dissemination of information has lagged far behind data collection.

The objective of this project was to identify and evaluate worthy landscape plants for use in the midwest.

Materials and Methods

Research trials have been established at sites on Kansas Agricultural Experiment Station fields in Manhattan, Hays, Colby, Tribune, Garden City, and Wichita. *Crataegus crus-galli* var. *inermis* (Thornless cockspur hawthorn), *Fraxinus excelsior* 'Kimberly' ('Kimberly' European ash), *Pistacia chinensis* (Chinese pistache), *Pyrus calleryana* 'Aristocrat' ('Aristocrat' callery pear), and *Quercus shumardii* (Shumard oak) were at each site in a randomized block design (five replications per site) at a 3.1 × 3.1 m (10 × 10 ft) spacing during spring 1984. *Acer platanoides* 'Greenlace' ('Greenlace' Norway maple), *Acer rubrum* (Red maple), *Cercocarpus montanus* (Mountain mahogany), *Phellodendron amurense* (Amur corktree), and *Quercus acutissima* (Sawtooth oak) were planted during the spring of 1985. Five species or cultivars have been added each subsequent year, but these will not be discussed in this paper. Test plants were selected on the basis of their potential landscape use, availability, and likelihood of environmental tolerance. Selections generally have been limited to named or commercially available species and cultivars, but some native species have been included. All plants were bareroot at planting unless otherwise indicated.

After the initial planting, care of the plants, except fertilization and pruning, was the responsibility of cooperating personnel at each site. Each plant was fertilized with 100 to 200 g (4 to 8 oz) of a low-nitrogen complete fertilizer during the spring of the first season after planting and subsequent years. Study personnel have pruned the plants as necessary.

Plant height and stem diameter [at 31 cm (12 in)] of new and existing plantings were measured each spring. All plantings were rated subjectively for foliage and overall quality, and survival was recorded during the summer. Plants were evaluated for 4 years. Although longer evaluation would be desirable, space availability and growth rates of the trees have limited the duration. Plants usually are moved to permanent locations on the Experiment Stations when testing is completed.

Relative growth of the plants was defined as height or stem diameter during the final measurement year divided

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Table 1. Average annual precipitation (cm), maximum summer and minimum winter temperatures (C), soil pH, and soil organic matter content (%) of the test sites in Kansas.

Variable	Manhattan	Hays	Colby	Tribune	Garden City	Wichita
1984 to 1988						
Precipitation[z] (cm)	82.6	57.7	40.9	38.6	38.5	76.2
Max. summer temp. (C)	40.9	42.9	40.5	39.7	40.6	41.5
Min. winter temp. (C)	−18.8	−19.0	−20.9	−21.1	−19.2	−19.7
1985 to 1989						
Precipitation[z] (cm)	69.6	50.9	31.7	35.2	36.3	75.8
Max. summer temp. (C)	41.0	43.3	40.2	39.6	40.0	40.7
Min. winter temp. (C)	−21.1	−21.7	−23.2	−24.0	−22.3	−21.5
Soil pH	8.0	6.8	7.6	7.9	8.3	6.6
Organic matter (%)	1.1	3.6	4.0	1.1	1.7	2.3

by the height or stem diameter at planting. This is a measure of the growth performance of the plant over the duration of the study. Relative growth data were analyzed as an ANOVA using PC-SAS. Only plants surviving through the final measurement year were considered, and missing data were ignored.

Site characteristics. The sites were diverse in their climatic and soil characteristics (Table 1). Precipitation and other environmental data are available for each location. Correlation between growth and environment is presently being attempted in a separate effort.

Results and Discussion

1984 Planting. Survival varied with species and site (Table 2). Some sites (especially Colby, Tribune, and Garden City) were quite dry (Table 2), and the plants suffered. Although differences in survival, growth, and quality were partly due to environmental factors, some were due to obvious variations in care. These parameters were better at sites where periodic irrigation was provided and weeds were controlled. Care has improved with time at all locations.

Average height and stem diameters of the species planted in 1984 for each site are presented in Tables 3 and 4. Height growth was generally greater at sites with a more moderate environment (Manhattan and Wichita). Stem diameter growth also followed this trend (Table 3). Foliage and overall quality ratings of the plants during 1986 and 1987 are presented in Table 5.

'Aristocrat' flowering pear. Some of the problems associated with survival of 'Aristocrat' pear were due to oversized nursery stock. The selection grew well in Manhattan, Wichita, and Hays. It suffered greatly in Garden City, where chlorosis was a severe problem. This was likely due to soil pH (8.3), aggravated by the dry conditions. Callery pear is not noted to be sensitive to iron chlorosis, and no yellowing of the leaves was apparent at any other sites with alkaline soil. The appearance and quality of 'Aristocrat' callery pear was excellent at the sites where it survived, except Garden City.

We did not find the clustering of major branches, which is a problem with 'Bradford', on the 'Aristocrat' trees in our trials. 'Aristocrat' is reported to have less acute branch angles and potentially a stronger growth habit than 'Bradford' (4). Fall color is reported to be variable and flowering somewhat more sparse than those of 'Bradford' (3). We found flowering and fall color of the plants in these trials very pleasing; trees flowered 1 to 2 weeks later than 'Bradford'. 'Bradford' pear sustained severe winter damage during 1987–88 and 1988–89 in central and eastern Kansas. Little or no injury was observed on 'Aristocrat' pear planted in the same vicinities. Fireblight has been reported to be a

Table 2. Survival (%) of 1984 Kansas statewide tree planting

Species	1984	1985	1986	1987	1988
	MANHATTAN				
'Aristocrat' Callery Pear	60	40	40	40	40
'Kimberly' European Ash	100	100	40	40	40[z]
Shumard Oak	80	80	80	80	80
Thornless Cockspur Hawthorn	80	80	80	80	80
Chinese Pistache	100	0	0	0	0
	HAYS				
'Aristocrat' Callery Pear	60	60	60	60	60
'Kimberly' European Ash	20	20	0	0	0
Shumard Oak	60	40	40	40	40
Thornless Cockspur Hawthorn	100	100	100	100	100
Chinese Pistache	80	20	20	20	20
	COLBY				
'Aristocrat' Callery Pear	0	0	0	0	0
'Kimberly' European Ash	0	0	0	0	0
Shumard Oak	0	0	0	0	0
Thornless Cockspur Hawthorn	100	100	100	100	100
Chinese Pistache	0	0	0	0	0
	TRIBUNE				
'Aristocrat' Callery Pear	0	0	0	0	0
'Kimberly' European Ash	20	20	20	20	20
Shumard Oak	40	40	40	40	40
Thornless Cockspur Hawthorn	80	80	80	80	80
Chinese Pistache	20	20	0	0	0
	GARDEN CITY				
'Aristocrat' Callery Pear	40	40	40	40	40
'Kimberly' European Ash	0	0	0	0	0
Shumard Oak	0	0	0	0	0
Thornless Cockspur Hawthorn	20	20	0	0	0
Chinese Pistache	100	100	80	80	80
	WICHITA				
'Aristocrat' Callery Pear	100	100	100	10	100
'Kimberly' European Ash	100	100	40	40	40[z]
Shumard Oak	40	40	40	40	40[z]
Thornless Cockspur Hawthorn	100	100	100	100	100
Chinese Pistache	100	100	100	100	100

[z]All remaining plants died during winter of 1988–89.

Table 3. Average height (m) of trees planted in 1984.

Location	1984	1985	1986	1987	1988
			'Aristocrat' Callery Pear		
Manhattan	2.02	2.02	3.03	3.69	4.80
Hays	1.88	2.11	2.47	2.91	3.13
Garden City	1.99	1.97	2.40	2.20	1.99
Wichita	2.11	1.99	2.69	3.66	4.44
Average	2.00	2.02	2.65	3.12	3.59
			'Kimberly' European Ash		
Manhattan	1.92	2.18	3.06	3.90	4.05
Tribune	1.88	2.00	2.20	2.46	2.95
Wichita	1.89	2.15	2.78	3.83	4.40
Average	1.89	2.11	2.68	3.40	3.80
			Shumard Oak		
Manhattan	2.09	2.21	2.63	3.09	3.30
Hays	2.35	2.14	2.20	2.44	2.53
Tribune	2.14	2.38	2.45	2.49	2.64
Garden City	2.16	2.28	2.50	2.60	2.63
Wichita	1.94	2.04	2.37	2.97	3.55
Average	2.14	2.21	2.43	2.72	2.93
			Thornless Cockspur Hawthorn		
Manhattan	1.86	2.07	2.28	2.57	2.63
Hays	1.92	2.15	2.20	2.36	2.48
Colby	1.99	2.06	2.14	2.27	2.27
Tribune	1.95	1.89	2.23	2.23	2.41
Wichita	1.95	1.91	2.19	2.64	2.66
Average	1.93	2.02	2.21	2.41	2.49
			Chinese Pistache		
Hays	1.79	1.96	2.80	2.90	3.23
Garden City	1.95	1.82	2.23	2.55	2.81
Wichita	1.83	1.98	2.66	3.11	4.14
Average	1.86	1.92	2.56	2.85	3.39

problem with 'Aristocrat' in the Southeast (3); however, we have seen no evidence of this disease in our study.

'Kimberly' European ash. This tree had problems at all sites. The original planting did not leaf out well for unknown reasons. Additionally, several plants were killed during the 1985 winter in Manhattan; some deer damage also occurred. Borer damage to 'Kimberly' ash in Wichita resulted in eventual tree mortality. All plants had died by mid-summer 1988 at Manhattan because of borers. We feel this is a questionable tree for widespread planting.

Shumard oak. As with 'Aristocrat' pear, survival of Shumard oak was affected by oversized nursery stock. The growth, appearance, and quality of Shumard oak was good where the original planting survived.

Shumard oak, a native of the south-central U.S., is similar in habit to pin and red oaks. However, it is resistant to the iron deficiency problem that pervades those species. It tolerated and grew in the alkaline soils in Manhattan and Garden City (Table 1). It was reliably hardy as far north as Manhattan, is considered a drought tolerant species in Oklahoma and Texas (3), and is reportedly native to southeastern Kansas (10). We would conditionally recommend this plant as an alternative to pin oak, based on its performance in these trials.

Thornless cockspur hawthorn. This was the only plant established during 1984 that survived at all sites. It seemed to be reasonably well adapted to all sites, although it was quite chlorotic at Garden City, where only one plant survived. Chlorosis was not a problem at the other locations nor has it been reported elsewhere as a difficulty. The foliage and overall quality of thornless cockspur hawthorn were outstanding, except in Garden City.

From our results and observations, we conclude that thornless cockspur hawthorn is a desirable plant for consideration in most Kansas landscapes. The flower and fruit displays are good, and we have seen only minimal incidence of rust on the foliage. This variety will likely be somewhat shorter at maturity than the species. The only "problem" we have encountered is some, but not extensive, suckering from the base. This can be handled easily by periodic pruning.

Chinese pistache. This species was reliably hardy only at the more southerly sites. All or most trees survived at Wichita and Garden City, plus a lone plant at Hays. It was tolerant of the alkaline conditions at Garden City (Table 1). Its growth, appearance, and quality at these sites were excellent. It certainly deserves wider consideration and planting in areas where it will be reliably winter hardy. The dark

Table 4. Average stem diameter (cm) of trees planted during 1984.

Location	1984	1985	1986	1987	1988
			'Aristocrat' Callery Pear		
Manhattan	3.23	3.45	4.51	8.30	9.98
Hays	3.16	3.09	3.50	5.20	6.12
Garden City	3.05	3.10	3.00	3.48	3.65
Wichita	3.19	3.62	4.65	5.25	8.36
Average	3.16	3.32	3.92	5.56	7.03
			'Kimberly' European Ash		
Manhattan	3.27	3.43	4.44	8.05	10.70
Tribune	3.17	2.88	3.80	5.82	8.20
Wichita	3.17	3.63	4.35	5.07	7.25
Average	3.20	3.31	4.20	6.31	8.72
			Shumard Oak		
Manhattan	2.93	2.96	3.46	4.93	6.89
Hays	2.77	2.95	2.25	3.30	3.52
Tribune	2.91	3.04	3.35	2.69	3.12
Garden City	2.80	2.99	2.50	3.07	3.10
Wichita	2.84	3.29	3.52	4.43	3.55
Average	2.85	3.05	3.02	3.68	4.04
			Thornless Cockspur Hawthorn		
Manhattan	3.03	3.17	3.63	4.39	5.50
Hays	2.88	2.96	2.68	3.53	4.21
Colby	2.88	3.06	2.24	3.15	4.17
Tribune	2.92	2.99	3.30	4.21	4.94
Wichita	3.11	3.46	3.64	4.56	5.28
Average	2.96	3.13	3.10	3.97	4.82
			Chinese Pistache		
Hays	2.90	2.86	3.50	6.00	8.95
Garden City	2.90	2.91	3.08	4.21	5.31
Wichita	3.04	3.57	4.76	4.46	7.02
Average	2.95	3.11	3.78	4.89	7.09

Table 5. Average foliage and overall quality ratings (1 = very poor and 5 = excellent quality for that site) for trees planted during 1984.

Location	1986 Foliage	1986 Overall	1987 Foliage	1987 Overall
	'Aristocrat' Callery Pear			
Manhattan	5.0	4.8	5.0	5.0
Hays	4.8	5.0	5.0	5.0
Garden City	2.0	2.8	1.3	1.3
Wichita	5.0	4.4	5.0	4.8
	'Kimberly' European Ash			
Manhattan	4.8	4.0	5.0	4.0
Tribune	3.5	5.0	5.0	5.0
Wichita	4.0	4.1	5.0	1.8
	Shumard Oak			
Manhattan	4.8	3.0	4.9	4.3
Hays	4.3	4.5	3.5	3.8
Colby	—	—	—	—
Tribune	3.3	3.3	3.5	3.3
Garden City	4.0	3.0	2.5	3.0
Wichita	5.0	4.0	5.0	3.5
	Thornless Cockspur Hawthorn			
Manhattan	4.7	4.2	5.0	5.0
Hays	4.8	4.6	3.8	4.5
Colby	3.6	4.1	4.4	4.4
Tribune	4.5	4.5	4.3	4.5
Wichita	5.0	4.9	5.0	5.0
	Chinese Pistache			
Hays	5.0	5.0	5.0	5.0
Garden City	4.5	3.9	4.2	3.8
Wichita	4.8	4.9	5.0	4.6

Table 6. Survival (%) of the 1985 statewide tree planting.

Location	1985	1986	1987	1988	1989
	Amur Corktree				
Manhattan	100	100	100	100	100
Hays	100	80	80	80	60
Colby	40	40	20	20	20
Tribune	100	100	100	100	100
Garden City	20	20	0	0	0
Wichita	100	100	100	100	100
Average	76.6	73.3	66.6	66.6	63.3
	Red Maple				
Manhattan	—[z]	—	—	—	—
Hays	100	100	100	100	100
Colby	20	20	20	0	0
Tribune	0	0	0	0	0
Garden City	0	0	0	0	0
Wichita	100	100	100	100	100
Average	44	44	44	40	40
	'Greenlace' Norway Maple				
Manhattan	0	0	0	0	0
Hays	20	20	20	20	20
Colby	40	40	20	0	0
Tribune	40	40	20	20	20
Garden City	0	0	0	0	0
Wichita	100	100	100	100	100
Average	33.3	33.3	26.6	23.3	23.3
	Sawtooth Oak				
Manhattan	100	100	100	100	100
Hays	100	100	100	100	100
Colby	100	100	100	100	100
Tribune	100	100	100	100	100
Garden City	80	80	80	60	60
Wichita	100	100	100	100	100
Average	96.6	96.6	96.6	93.3	93.3
	Mountain Mahogany				
Manhattan	20	20	20	20	20
Hays	100	100	100	100	100
Colby	20	20	20	20	20
Tribune	100	100	80	80	80
Garden City	100	80	60	60	60
Wichita	100	60	60	40	40
Average	73.3	63.3	56.6	53.3	53.3

[z]Not planted

green summer foliage is quite attractive, and the orange to orange-red fall color is outstanding. Fruit of the female plants turn from red to robin's-egg blue as they mature in the fall. Some named selections have been made (2, 3) but they are scarce in the trade because of difficulties in asexual propagation.

Table 7. Average plant height (m) of trees planted in 1985.

Location	1985	1986	1987	1988	1989
	Amur Corktree				
Manhattan	1.16	1.02	2.12	2.97	3.45
Hays	1.11	0.46	1.08	1.72	1.51
Colby	1.10	1.10	0.86	1.00	1.44
Tribune	1.43	1.08	1.38	1.27	1.45
Wichita	1.13	1.12	1.76	2.19	2.65
	Red Maple				
Hays	1.54	1.55	1.90	2.40	2.55
Colby	1.59	1.60	1.64	—	—
Wichita	1.72	1.79	2.20	2.57	3.00
	'Greenlace' Norway Maple				
Hays	1.61	1.61	1.74	1.79	1.92
Tribune	1.85	1.85	1.90	2.00	1.92
Wichita	1.98	1.98	2.00	2.09	2.47
	Sawtooth Oak				
Manhattan	1.27	1.13	1.59	2.62	3.74
Hays	0.96	1.14	1.56	2.16	2.38
Colby	1.26	0.96	1.23	1.55	1.98
Tribune	1.28	1.34	1.59	1.88	2.37
Garden City	1.24	1.30	1.33	1.39	1.61
Wichita	1.05	1.46	2.12	3.25	4.19
	Mountain Mahogany				
Manhattan	.28	.60	.88	1.00	1.47
Hays	.29	.20	.52	.85	1.04
Colby	.40	1.10	.72	1.10	1.38
Tribune	.28	.21	.61	1.05	1.20
Garden City	.21	.38	.98	1.19	1.43
Wichita	.28	.41	.49	.62	.69

1985 Planting. Survival of the 1985 planting was somewhat better than that of the 1984 study (Table 6). Survival of the test species undoubtedly reflected environmental stress and, to a lesser extent, the amount of supplemental care at some locations. Those plants from containers (sawtooth oak seedlings and mountain mahogany) survived better than bare-root plants.

Average plant heights are presented in Table 7 and stem diameters in Table 8. Summer foliage and overall subjective quality ratings for the 1985 planting are presented in Table 9.

Amur corktree. Amur corktree initially survived well at all locations, except Colby and Garden City (Table 6), where it suffered losses during the 1986–87 winter. The plant grew at all locations where it survived, showing the most dramatic growth at Manhattan and Wichita. It often suffered winter dieback (Table 7) at each site, developed an irregular form and required considerable pruning. Female seedlings of the species have been noted to be more prone to winter twig dieback and to develop a "bushier" form than male trees. This may be an adaptation to increase the number of female flowers and, therefore, the species (Willet Wandell, personal communication). A male selection, 'Macho', is available in the trade (11). Stem diameter growth (Table 8) followed the same trends as height growth but increased at a more consistent rate than height. Thus, they may better reflect environmental influences upon growth.

Foliage of Amur corktree tended to scorch and tatter at most locations. The overall quality of the plant was poor, except in Manhattan, because of the poor form, continuous problems with winter dieback, and poor foliage quality (Table 9).

The performance and appearance of Amur corktree were disappointing. This species is often recommended because of its presumed tolerance of drought, temperature, pH, soil type, and urban conditions. The seedling plants in this study were apparently severely affected by winter temperatures, and the foliage was stressed by the Kansas summer. Dirr (3) indicated that the tree may not be as "tough" as reported in the literature. We concur, and find little reason to recommend this species for general use.

Red maple. Red maple became established only at Hays and Wichita because of poor stock and/or care. A shipping error by the nursery prevented its planting at Manhattan. The plant grew well at both Wichita and Hays.

Foliar quality of red maple was good at both locations (Table 9). The plants were seedlings from a northern seed source, so they did not react to the environment uniformly. Chlorosis was minimal at Hays and not a problem in Wichita. Chlorosis appeared to be related to drought conditions. Scorching of the leaves was intermittent and minimal and did not detract from overall plant quality.

The plant performed surprisingly well at Hays, a more stressful environment than typical for adequate performance of the species. Manganese deficiency has resulted in widespread problems in high pH soils in many areas (3). This may limit the plant's use in Kansas. Soils at Wichita and Hays were slightly acidic (Table 1). Further evaluation of red maple, particularlay its cultivars on their own roots, is certainly warranted. This species must be more extensively studied before a recommendation can be made. We would expect it to perform best in managed landscapes.

'Greenlace' Norway maple. Establishment of 'Greenlace' Norway maple was disappointing, except at Wichita. This may have been related to the quality of the nursery stock received. The growth rate of 'Greenlace' Norway maple is listed as moderate (3) but was poor in this study (Tables 7 and 8).

'Greenlace' Norway maple produces deeply cut, lace-like leaves (3). The dissect foliage was interesting but did not produce an overall fine-textured appearance for the tree. The foliage tended to scorch during the summer, except in Wichita. Although the overall quality of the plant was rated as "good" (Table 9), growth and development were slow. The cultivar is unusual and will likely remain a curiosity. However, because of its poor performance in our study and limited aesthetic contribution to the landscape, we would not recommend widespread planting in the high plains.

Sawtooth oak. Sawtooth oak, obtained in 7.5 l (2-gal) polyfilm bags, survived well at all sites (Table 6). The plant grew significantly taller at Wichita and Manhattan than at the other locations (Tables 7). Growth rate for this characteristically moderate-to-slow growing species was reasonable in Manhattan and Wichita, averaging about 40% per year. Slower growth under the harsher conditions existing at the other sites place it in the "valued, but long-term investment" class of shade trees at these locations, similar to bur oak (*Quercus macrocarpa*). Sawtooth is one of the smaller oaks hardy in the Midwest (3).

Leaf quality of Sawtooth oak was good to excellent at

Table 8. Average stem or plant diameters (cm) of plants established in 1985.

Location	1985	1986	1987	1988	1989
	Amur Corktree				
Manhattan	1.46	1.94	4.30	7.41	9.98
Hays	1.56	1.63	1.93	3.02	3.34
Colby	1.66	1.40	1.83	2.35	3.04
Tribune	1.62	1.56	1.97	2.71	3.62
Wichita	1.78	2.09	3.25	4.04	5.52
	Red Maple				
Hays	1.87	1.83	2.42	3.10	3.19
Wichita	2.01	2.32	2.67	3.36	4.37
	'Greenlace' Norway Maple				
Hays	1.72	1.80	2.25	2.74	3.25
Tribune	1.64	1.45	2.00	2.67	3.19
Wichita	1.79	1.98	2.62	3.30	4.57
	Sawtooth Oak				
Manhattan	1.28	1.59	3.33	5.79	8.46
Hays	1.27	1.52	3.06	4.02	4.43
Colby	1.36	1.13	1.80	2.73	3.85
Tribune	1.20	1.44	2.20	3.46	4.68
Garden City	1.08	1.18	2.01	2.50	3.14
Wichita	1.40	1.75	3.13	4.44	6.39
	Mountain Mahogany[z]				
Manhattan	12.00	36.00	82.00	65.00	80.00
Hays	5.50	8.00	20.00	22.00	30.80
Colby	12.00	15.00	15.00	60.00	65.00
Tribune	12.60	12.00	24.00	54.00	80.00
Garden City	12.40	—	43.90	73.70	106.70
Wichita	18.80	14.60	41.00	—	44.00

[z]Shrub, data represent average plant diameter.

Table 9. Mean summer foliage and overall plant quality (1 = poor and 5 = excellent for living trees at that site) for the 1985 Kansas tree planting.

Location	Foliage Quality 1986	1987	1988	Overall Quality 1986	1987	1988
			Amur Corktree			
Manhattan	3.9[z]	4.4	4.1	3.8	3.7	4.4
Hays	4.8	3.4	2.3	3.0	3.5	1.9
Colby	3.5	2.0	2.8	1.5	2.0	2.8
Tribune	2.8	3.2	3.6	2.7	2.7	3.4
Garden City	—	—	—	—	—	—
Wichita	4.4	3.0	2.0	4.6	3.5	2.0
Average	3.8	3.2	3.7	3.1	3.0	2.5
			Red Maple			
Manhattan	ND[y]	ND	ND	ND	ND	ND
Hays	3.7	4.3	3.8	3.6	4.7	4.3
Colby	2.5	4.0	—	3.0	4.0	—
Tribune	—	—	—	—	—	—
Garden City	—	—	—	—	—	—
Wichita	4.2	3.5	3.0	4.0	3.0	3.0
Average	3.4	3.9	3.4	3.5	3.9	3.6
			'Greenlace' Norway Maple			
Manhattan	—	4.0	—	—	5.0	—
Hays	2.5	3.0	2.8	2.5	3.0	3.0
Colby	2.5	3.3	—	2.5	3.5	—
Tribune	3.0	3.0	4.0	3.0	3.0	5.0
Garden City	—	—	—	—	—	—
Wichita	4.0	4.0	4.0	4.0	4.0	4.0
Average	3.0	3.4	3.6	3.0	3.7	4.0
			Sawtooth Oak			
Manhattan	3.0	4.3	5.0	4.0	4.3	4.8
Hays	4.6	4.7	4.6	3.6	4.9	4.6
Colby	3.9	4.2	4.1	2.9	4.1	4.1
Tribune	4.7	4.5	4.7	4.4	4.1	3.9
Garden City	3.9	2.6	3.5	4.2	2.8	2.7
Wichita	5.0	5.0	5.0	5.0	5.0	5.0
Average	4.1	4.2	4.5	4.0	4.2	4.2
			Mountain Mahogany			
Manhattan	5.0	3.0	4.0	4.2	4.0	5.0
Hays	4.8	4.5	4.6	4.2	4.8	4.4
Colby	5.0	4.0	3.5	4.0	5.0	4.0
Tribune	5.0	4.6	4.8	4.5	4.6	4.5
Garden City	4.9	4.7	4.0	4.2	4.7	4.0
Wichita	2.8	3.5	3.5	2.2	3.5	3.5
Average	4.5	4.0	4.1	3.8	5.2	4.2

[z]Average of living plants

most locations (Table 9). Chlorosis was an intermittent problem at Garden City but was apparently more related to soil moisture than to soil pH. It was observed on some seedlings during some of the annual evaluations but was completely absent during other site visits. The plant has the potential to be an attractive, medium-sized, long-term addition to the landscape for many areas of the Midwest.

Mountain mahogany. Mountain mahogany, from 3.8 l (1-gal) containers, survived well at all sites, but overall survival was generally greater at the drier test sites (Table 6). This native of the Western United States (8) is tenacious and should tolerate and grow in the intemperate areas of western Kansas.

The leaves are small (1 to 3 cm long), dark green, obovate, and attractive (1). Foliage and overall quality of mountain mahogany were good to excellent at all locations (Table 9). Unfortunately, the plant has little to offer in floral display, fall color, form (irregular), or other aesthetic attributes. Nevertheless, it is a plant to consider for low-maintenance situations or for harsh environments. Availability from wholesale nurseries is currently limited to some firms in the western states.

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Kairomone Response, Pesticide Tolerance and Field Efficacy of the Predatory Mite, *Neosieulus collegae* (De Leon)[1]

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Abstract

Neosieulus (*Cydnodromus*) *collegae* (De Leon) (Acari:Phytoseiidae) is a heretofore relatively unknown species of predatory mite. In an olfactometer, female predators were attracted to kairomones produced by *Tetranychus urticae* Koch, *Oligonychus ilicis* (McGregor), *O. ununguis* (Jacobi), *Eotetranychus hicoriae* (McGregor), and *E. sexmaculatus* (Riley). Predators were repelled by odors emanating from lima bean leaves treated with Mavrik (fluvalinate) and Ammo (cypermethrin), but unresponsive to those treated with Tame (fenpropathrin) and Talstar (bifenthrin). This predator species was tolerant of residues of Vendex (hexakis), Omite (propargite), Pentac (dienochlor) and Avid (abamectin) but not to residues of Tame (fenpropathrin) and Kelthane (dicofol). Eggs of *T. urticae* treated with Tame (fenpropathrin) were toxic to the predator when consumed. Female *N. collegae* would not consume eggs treated with Avid (abamectin); starvation reduced fecundity. Prey eggs treated with Vendex (hexakis) and Omite CR (propargite) were consumed without affecting predator fecundity or mortality. Eggs treated with Pentac (dienochlor) or Kethane (dicofol) were consumed, but significantly reduced predator fecundity. Predators released into plots in a commercial nursery during winter in north Florida reduced field populations of *T. urticae* within 20–30 days, if released in high numbers. *Neosieulus collegae* may have significant potential as a biological control agent in nursery crops for control of mite pests.

Index words: Acari, Phytoseiidae, acaricide, kairomone, biological control

Pesticides/Kairomones used in the study: Pentac AF (dienochlor), decachloro bis(2-4-cyclopentadiene-1-y); Tame 2.4 EC (fenpropathrin), alpha-cyano-3-phenoxybenzyl 2,2,3,3-tetramethyl-1-cyclopropane carbaroxylate; Vendex 4L (hexakis), hexakis (2-methyl-2-phenylpropyl) distannoxane; Avid 0.15EC (abamectin), avermectin B_1a; Omite CR (propargite), 2-(p-tert-butylphenoxy)cyclohexyl 2-propynyl sulfite; Ammo 2.5EC, (cypermethrin), (±) cyano (3-phenoxyphenyl)methyl (±) cis-trans 3-(2,2-dichloroethenyl)-2,2 dimethylcyclopropane-carboxylate; Kelthane 35WP (dicofol), 1,1-bis(chlorophenyl)-2,2,2-trichloroethanol; Talstar 10WP (bifenthrin), (2 methyl[1,1-biphenyl]-3-yl) methyl 3-(2-chloro-3,3,3,3-trifluoro-1-propenyl)-2,2dimethylcyclopropanecarboxylate; Mavrik AF (fluvalinate), N-[2-chloro-4-(trifluoromethyl) phenyl]-D-valine (±)-alpha-cyano-(3-phenoxyphenyl)methyl ester.

Significance to the Nursery Industry

This research indicates that the predatory mite, *N. collegae*, has excellent potential as a biological control agent for spider mites in landscape plants. The predator is able to tolerate several acaricides, is attracted to kairomones of a variety of mite pest species, and appears capable of rapidly controlling spider mites in the field, when released in reasonably high numbers. Future research should determine the optimum predator-to-prey release ratio and the impact of nursery management practices on the predator's ability to regulate populations of various pest species.

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Introduction

Landscape nursery crops are attacked by many pests. Aesthetic thresholds require control at low pest numbers to maintain quality plants. Spider mites are the most important pests of container-grown woody landscape plants in terms