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Boron Tolerance of Twenty-five Ornamental Shrub Species[1]

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Abstract. **Boron (B) tolerance of 25 ornamental shrub species was determined in large, outdoor sand cultures. Tolerant species such as Natal plum (*Carissa grandiflora* (E. H. Mey.) A. D. C.), Indian hawthorn (*Raphiolepis indica* (L.) Lindl.), Chinese hibiscus (*Hibiscus rosa-sinensis* L.), oleander (*Nerium oleander* L.), Japanese boxwood (*Buxus microphylla* Siebold and Zucc.), bottlebrush (*Callistemon citrinus* (Curtis) Stapf), ceniza (*Leucophyllum frutescens* (Berland.) I. M. Johnst.), and blue dracaena (*Cordyline indivisa* (G. Forst) Steud.) were affected little, if at all, by 7.5 mg B/liter in the irrigation water. Sensitive species like yellow sage (*Lantana camara* L.), juniper (*Juniperus chinensis* L.), Chinese holly (*Ilex cornuta* Lindl. and Paxt.), Wax-leaf privet (*Ligustrum japonicum* Thunb.), laurustinus (*Viburnum tinus* L.), thorny elaeagnus (*Elaeagnus pungens* Thunb.), xylosma (*Xylosma congestum* (Lour.) Merrill), photinia (*Photinia* X *Fraseri* Dress.), and Oregon grape (*Mahonia aquifolium* (Pursh) Nutt.) were severely damaged or killed by 7.5 mg B/liter and moderately damaged by 2.5 mg B/liter in the irrigation water. B tolerance and B accumulation in the leaves were not correlated and no correlation was found between B tolerance and salinity tolerance.**

Boron (B) toxicity of plants in the United States if primarily confined to a few irrigated areas in the West and secondarily to over fertilization with B fertilizer. Although excess B problems do not involve a large area, plant injury can be severe. The most common source of B in soils is from irrigation water pumped from wells with high B contents and, to a lesser extent, from very shallow water tables and soils naturally high in B. Most irrigation waters drawn from surface streams are low in B (5).

The B tolerance of a wide variety of plants has been tested over the years including major crop plants (4, 6, 8, 12, 13) and native species (3, 11). However, information on B tolerance of ornamentals, is severely lacking and especially needed where urban development is taking place on land that was previously irrigated with water containing B. This study was conducted to determine the B tolerance of 25 ornamental species often used in landscaping where excess B is a problem.

Methods and Materials

Twenty-five shrub species (Table 1), growing in 4-liter containers, were purchased from a commercial nursery, and transplanted on March 7, 1973, into 15 large outdoor sand tanks. Before transplanting, the soil was washed from the roots. Five tanks were used for each B treatment and each species was replicated twice within a treatment by planting 10 species in each tank. The tanks were 4.3 m long × 0.76 m wide × 0.76 m deep, filled with a coarse river sand. Each sand tank had a 2400-liter irrigation reservoir in addition to 400 liters of irrigation water retained in the sand. Culture solutions were surface applied automatically twice daily to completely flush the sand tanks and were returned to the reservoir. Boron treatments, 0.5, 2.5, and 7.5 mg B/liter, were added as H_3BO_3 to tap water on April 23, 1973. These levels included 0.1 mg B/liter as impurities in the nutrient salts and 0.06 mg B/liter in tap water. Boron levels were monitored monthly to maintain desired levels. The study was terminated on January 20, 1976 (33 months later).

The base nutrient solution contained 2, 1.5, 1.0, 0.5 mM of $Ca(NO_3)_2$, KCl, $MgSO_4 \cdot 7\ H_2O$, and $NH_4H_2PO_4$, respectively, and 0.5 mg/liter Fe as iron citrate, 0.25 mg/liter Mn as $MnCl_2$, 0.025 mg/liter Zn as $ZnSO_4$, 0.01 mg/liter Cu as $CuSO_4$, and 0.005 mg/liter Mo as molybdic acid. Tap water was added to the irrigation reservoirs about every 3 weeks to replenish water lost by evapotranspiration. Nutrient salts were also added in proportion to the amount of water replenished. Sulfuric acid was added to lower the pH to the range of 6 to 7. Culture solutions were changed completely once each year in midwinter.

All shrubs were pruned during the winter, or more frequently as required. Pruning weights were added to top weights to determine total top growth (uncorrected for initial top weight). Appearance assessment was made throughout the experiment, because aesthetic value is often more important than growth rate for ornamentals.

Leaf samples for B analysis were collected annually in October and when injury symptoms developed. Injured and uninjured leaves of comparable age were sampled from the same plant whenever possible. Boron was determined colorimetrically by the Carmine method (9).

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Table 1. Leaf symptoms of B injury and growth reduction of 25 shrub species at 2.5 and 7.5 mg B/liter compared with the control treatment of 0.5 mg B/liter. (LB = low concentration boron; HB = high concentration).

Species[z]	General observations	Growth reduction (%)
Tolerant		
Natal plum (*Carissa grandiflora* (E. H. Mey.) A. DC. cv. Tuttlei)	LB: No injury	0
	HB: No injury	0
Indian hawthorn (*Raphiolepis indica* (L.) Lindl. cv. Enchantress)	LB: No injury	0
	HB: No injury	0
Chinese hibiscus (*Hibiscus rosa-sinensis* L.)	LB: No injury	0
	HB: Slight premature leaf drop	0
Oleander (*Nerium oleander* L.)	LB: No injury	21
	HB: Narrow (1 to 2 mm) marginal chlorosis-slight tip burn	24
Japanese boxwood (*Buxus microphylla* Siebold and Zucc. var. *japonica* (Mull. Arg.))	LB: No injury	0
	HB: General marginal chlorosis with necrotic older leaves	0
Bottlebrush (*Callistemon citrinus* (Curtis) Stapf)	LB: Slight marginal coloration similar to HB	0
	HB: Marginal anthocyanin coloration (5 mm from leaf tip) progressed inward in semicircle pattern toward midrib; marginal and tip necrosis developed as leaves matured	0
Ceniza (*Leucophyllum frutescens* (Berland.) I. M. Johnst. cv. Compactum)	LB: No injury	15
	HB: Older leaves dropped prematurely	24
Blue dracaena (*Cordyline indivisa* (G. Forst) Steud.)	LB: Tip burn, 5 to 7 cm (1973 10 to 13 cm (1975)	0
	HB: Tip burn, 7 to 10 cm (1973) 18 to 22 cm (1975)	0
Semi-tolerant		
Brush cherry (*Syzygium paniculatum* Gaertn.)	LB: Slight anthocyanin spotting oldest leaves	0
	HB: Moderate anthocyanin spotting; oldest leaves dropped prematurely; general appearance chlorotic	11
Southern yew (*Podocarpus macrophyllus* (Thunb.) D. Don var. *Maki* Endl)	LB: Slight tip burn with narrow chlorotic band between burn and remainder of leaf	0
	HB: Moderate to severe tip burn (1 cm) with narrow chlorotic area like LB – leaves on lower ¾ plant exhibited burn	8
Oriental arborvitae (*Platycladus orientalis* (L.) Franco)	LB: Slight chlorosis to necrosis on tips older leaves	27
	HB: Severe necrosis older leaves – only outside perimeter of plant was still green	30
Rosemary (*Rosmarinus officinalis* L.)	LB: Tip necrosis older leaves	20
	HB: Tip necrosis all leaves	51
Glossy abelia (*Abelia* × *grandiflora* (Andre) Rehd.)	LB: Bronzing and tip burn older leaves	56
	HB: Bronzing all leaves, slight leaf drop	70
Sensitive		
Yellow sage (*Lantana camara* L.)	LB: Tip and marginal leaf burn intermediate and older leaves, some hastened leaf drop	14
	HB: Moderate to severe leaf burn all leaves, severe leaf drop	82
Juniper (*Juniperus chinensis* L. cv. Armstrongii)	LB: Moderate tip burn older leaves	20
	HB: Severe tip burn all leaves except oustide perimeter of new leaves – center leaves of plant dead	47
Chinese holly (*Ilex cornuta* Lindl. and Paxt. cv. Burfordii)	LB: Some marginal burn and interveinal chlorosis	17
	HB: Tip and marginal burn all leaves – premature leaf drop	88
Japanese pittosporum (*Pittosporum tobira* (Thunb.) Ait.)	LB: Marginal and tip burn distal half older leaves – premature leaf drop	50
	HB: Premature leaf drop all leaves except very youngest – young leaves chlorotic with moderate to severe marginal and tip burn – small rosettes young leaves at branch tips	50

(Continued)

Table 1. (Continued)

Species[z]	General observations	Growth reduction (%)
Spindle tree (*Euonymus japonica* Thunb. cv. Grandifolia)	LB: Slight tip burn, slight leaf drop	4
	HB: Severe chlorosis and tip burn all leaves, severe leaf drop	100
Pineapple guava (*Feijoa sellowiana* O. Berg.)	LB: Slight tip burn 1st year – moderate leaf drop, moderate tip and marginal burn 1974 and 1975	13
	HB: Severe leaf drop – all leaves showed severe tip and marginal burn – youngest leaves also chlorotic	35
Wax-leaf privet (*Ligustrum japonicum* Thunb.)	LB: No apparent injury symptoms except reduced growth	17
	HB: Terminal 1/2 to 2/3 of branches dead – necrotic spotting older leaves, nearly completely defoliated	100
Laurustinus (*Viburnum tinus* L. cv. Robustum)	LB: Marginal and tip burn intermediate and older leaves, moderate leaf drop	0
	HB: Severe tip and marginal burn, all leaves, except very youngest	100
Thorny elaeagnus (*Elaeagnus pungens* Thunb. cv. Fruitlandii)	LB: Older leaves interveinal and marginal chlorosis on distal half of leaf	11
	HB: Severe chlorosis with marginal necrosis, severe leaf drop nearly all but youngest leaves, remaining leaves hyponastic	70
Xylosma (*Xylosma congestum* (Lour.) Merrill)	LB: Older leaves anthocyanin mottling and tip burn, more severe by mid-Summer, severe leaf drop older leaves	23
	HB: Many branches dead, anthocyanin mottling and severe tip burn all leaves, nearly complete leaf drop	100
Photinia (*Photinia* × *Fraseri* Dress)	LB: Marginal and tip burn older leaves	0
	HB: Severe leaf burn, severe leaf drop – stem tips dead, death mid-1974	100
Oregon grape (*Mahonia aquifolium* (Pursh) Nutt.)	LB: Tip necrosis young leaves, severe leaf drop older leaves	50
	HB: Severe leaf drop except very youngest – severe burn older and intermediate leaves, tip burn young leaves, barely survived 1st year (1973)	100

[z]Species listed in descending order of tolerance.

Results and Discussion

The B tolerance of the 25 shrub species is presented in Table 1 in decreasing order of tolerance and are classified as tolerant, semitolerant, or sensitive. There is no sharp line of demarcation between categories. These classifications are based on both growth reduction and overall shrub appearance. Some species, like oleander and ceniza, are classified as tolerant since their esthetic value is considered more important than reduction in growth. In general, the semitolerant and sensitive shrubs suffered in appearance, as well as growth reduction.

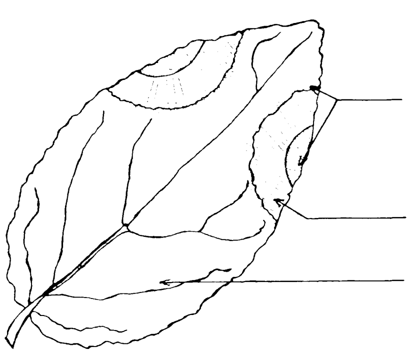

Fig. 1. Leaf injury on Bottlebrush.

Evaluation of species response to B is given in Table 1 in terms of injury description and percent growth reduction. Early injurious effects of B were usually observed on the leaves as marginal chlorosis or necrosis, tip burn, cupping of leaves, necrotic spots between veins, reduced leaf size, premature leaf drop or development of anthocyanins. Similar injury symptoms have been reported for several plants (5, 10). These types of injury are reported as caused by excess B carried to the leaves in the transpirational stream, where it moves from the veins into the interveinal tissue and accumulates at the leaf tip and margins (1,6). Bottlebrush developed leaf injury which may be unique to that species. The initial visual injury symptom was the development of an anthocyanin semicircle on the leaf margin about 5 mm from the tip. As injury became more severe the semicircle increased in circumference with a chlorotic area between the anthocyanin on the margin and a very narrow band of anthocyanin between the chlorotic area and the healthy leaf tissue (Fig. 1). The leaves never became completely injured.

No correlation was found between B tolerance and B

Table 2. Leaf B concentrations of 25 shrub species at three nutrient B levels.

Species	Leaf B concentration (mg/kg dry weight)			
	B concentration (mg/liter)			
	0.5	2.5	7.5	B damaged leaves[z]
Natal plum	62	261	632	–
Indian hawthorn	57	94	164	440
Chinese hibiscus	53	67	140	–
Oleander	83	240	288	667
Japanese boxwood	106	416	646	1250
Bottlebrush	85	277	706	917
Blue dracaena	68	85	180	–
Ceniza	65	81	157	–
Brush cherry	108	389	550	1030
Southern yew	74	202	294	690
Oriental arborvitae	80	167	391	413
Rosemary	55	152	327	626
Glossy abelia	153	288	1074[y]	1470
Yellow sage	92	286	399	716
Juniper	43	126	292	325
Chinese holly	109	426	674[x]	994
Japanese pittosporum	63	234	669	742
Spindle tree	59	182	206	416
Wax-leaf privet	35	134	318	446
Pineapple guava	74	300	782	1020
Laurustinus	106	364	729	1212
Thorny elaeagnus	113	329	348	585
Xylosma	101	259	551	785
Photinia	90	144	254	1102
Oregon grape	128	347	618	994

[z]Lowest concentration B found in damaged leaves.

[x]Marginal chlorosis.

[y]Dull bronzed and tip burn.

accumulation in leaves (Table 2). The highly tolerant Natal plum accumulated 261 and 632 B/kg dry weight at the 2.5 and 7.5 mg/liter B treatments, respectively, with no leaf injury nor growth reduction. In contrast, the spindle tree, wax-leaf privet and throny elaeagnus showed considerable leaf burn and growth reduction at 416, 446, and 585 mg B/kg dry weight, respectively.

Leaves of the blue dracaena exhibited tip burn at all B levels. The leaf tips, when analyzed separately from the healthy leaf tissue, showed extremely high B accumulation. The control plants, with only 0.5 mg B/liter in the irrigation water, contained 8615 mg B/kg dry weight in the tips, whereas the remaining tissue contained only 68 mg B/kg dry weight. The 2.5 and 7.5 mg/liter B treatments showed similar results with 9960 and 11297 mg/B per kg in the tips, respectively. Eaton (5) reported similar findings when he analyzed the burned tips of eureka lemon (*Citrus limon* (L.) Burm. F.) leaves separately from the rest of the leaf.

The injury which develops is closely related to the type of leaf venation. The blue dracaena, rosemary, and southern yew, all with parallel venation, showed tip burn and no marginal injury. Shrubs with pinnate or palmate venation, however, exhibited both tip and marginal burn. Similar symptoms have been reported by Oertli and Kohl (10) for other species.

Since B accumulates predominantly in the leaf tissue, without later translocation (6), fall or winter pruning removes much of the accumulated B. Consequently, the new spring growth will contain low B levels.

Climatic conditions can play an important role in B tolerance, since the movement of B to the leaves is governed by transpiration. Under the hot (35°C), dry (30% relative humidity) summer conditions in Riverside, California, B will accumulate considerably faster than under a cool, wet climate. Injury may occur in the hot, dry climate but not in the cool, wet climate, although soil B concentrations are similar.

No correlation was found between B tolerance and the reported salt tolerance of these shrubs (2, 7). Yellow sage and juniper, both sensitive to B, are moderately tolerant to salinity; whereas Chinese hibiscus, which is tolerant to B, is very sensitive to salinity. Natal plum and Oleander are tolerant to both stress conditions, whereas Chinese holly and pineapple guava are sensitive to both conditions. While excess B may be associated with saline irrigation water, the B tolerance of individual species to such conditions are not necessarily related to salt tolerance.

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