Journal of the Minnesota Academy of Science

Volume 14 | Number 1 Article 5

4-1946

Alkali Tolerance of Drought-Hardy Trees and Shrubs in the Seed and Seedling Stage

Joseph H. Stoeckeler

species from Lake Pepin and Winona areas, and from the one growing locally in Duluth as a probable garden escape which was reported by the writer as *P. occidentale* Greene.[1]

For adequate study material the writer made a collecting trip on July 2, and another a month later for fruiting specimens. The collections were referred to *P. occidentale* Greene, but differed from the typical material by larger upper cauline leaves and eglandulose pubescence. It was recalled that in 1935 Dr. E. T. Wherry requested the writer to look for species of *Polemonium* in swamp habitats. Specimens were submitted to him who after a careful study described a new subspecies under the following epithet: *Polemonium occidentale lacustre* Wherry,[2] basing the subspecies on the writer's collection No. 5575 from a colony in an arborvitae swamp, 3½ mi. n. of Sturgeon Lake Observation Tower (47–50, 93–00) St. Louis Co., Minn. Type in the herbarium Academy Natural Sciences, Philadelphia; replicates in the herbaria of the University of Minnesota and Duluth State Teachers College.

The Sturgeon Lake colony, about an acre in extent, is the only known one in the state. It appears to be an isolated eastward extension of a western species of wide distribution from the Rocky Mountains to the Pacific coast.

ALKALI TOLERANCE OF DROUGHT-HARDY TREES AND SHRUBS IN THE SEED AND SEEDLING STAGE[1]

JOSEPH H. STOECKELER
Lake States Forest Experiment Station

In extensive travel in the Great Plains, the writer has observed that there appears to be a considerable difference in the ability of various species of trees and shrubs to tolerate alkalinity in the soil. To act as a check on field observations, it was believed that the relative tolerance of various species might be arrived at by laboratory methods involving the placing of seed or recently germinated seedlings in alkali solutions of several types and concentrations. The technique used was similar to that of Breazeale (1926).[2]

It was hoped that a scale of relative alkali tolerance could be devised which would be of use to nurserymen and tree planters. Alkali tolerance is known to vary by age of plant—the older plants

[1] Lakela, Olga. Rhodora 40(475): 280. 1938.
[2] Wherry, E. T. Am. Midl. Nat. 34(2): 376–377. 1 fig. 1945.

[1] This paper is a condensed version of a report on a project performed as a special graduate problem under the direction of the late Dr. R. B. Harvey, Professor of Plant Physiology, University of Minnesota.
[2] Breazeale, H. F. Alkali tolerance of plants considered as a phenomenon of adaptation. University of Arizona Tech. Bul. 11, Nov. 1, 1926.

being more resistant than young plants. However, the relative position of plants arranged by species in a scale of decreasing alkali tolerance is fairly close for young and old plants.

In the tests, two types of alkali were used, namely a typical white alkali (sodium sulphate) and black alkali (sodium carbonate). These were made up in a range of concentrations, the first test being preliminary to determine approximate lethal point, the second repeating the significant part of the range. One series of tests involved ungerminated seeds placed on blotters in large petri dishes of known concentration of the chemical. Another series required seeds which had sprouts one or two centimeters long, the ends of which were placed even with a line on the blotters on which they rested. The petri dishes were kept in a humidity chamber to prevent heavy evaporation loss and consequent concentration of the alkali solutions.

The criterion of limit of alkali tolerance was determined by the ability of the majority of the seed to germinate in a 30-day period, and in case of pregerminated seed to elongate the hypocotyl beyond its original extent.

The seed was pretreated with the best technique known to break dormancy. All seeds were thoroughly washed and rinsed repeatedly after treatment and before placing into petri dishes.

Treatments used are listed below:

Legumes with hard seed coats

Black locust (*Robinia pseudoacacia* L.) 30 minutes concentrated sulphuric acid

Skunk sumac (*Rhus trilobata* Nutt.) 20 minutes concentrated sulphuric acid

Honey locust (*Gleditsia triacanthos* L.) 50 minutes concentrated sulphuric acid

Kentucky coffee-tree (*Gymnocladus dioicus* (L) Koch.) 4 hours concentrated sulphuric acid

Species requiring stratification at 5 to 10° C. in moist sand

Rocky Mountain red cedar (*Juniperus scopulorum* Sargent) 375 days

Eastern red cedar (*Juniperus virginiana* L.) 120 days

Russian olive (*Elaeagnus angustifolia* L.) 120 days

Green ash (*Fraxinus pennsylvanica* lanceolata (Borkh.) Sargent) 90 days

Boxelder (*Acer negundo* L.) 90 days

Buffalo-berry (*Shepherdia argentea* Nutt.) 90 days

Choke cherry (*Prunus virginiana* L.) 120 days

Wild plum (*Prunus americana* Marsh.) 120 days

Species improved by water soaking

Osage orange (*Toxylon pomiferum* Raf.) 5 days

TABLE 1.—ALKALI TOLERANCE OF SEEDS AND SEEDLINGS OF DROUGHT-HARDY TREES AND SHRUBS ADAPTED TO SUBHUMID AND SEMI-ARID REGIONS

Species	Relative alkali tolerance and limit of endurance in parts per million							
	White alkali (sodium sulphate)				*Black alkali (sodium carbonate)*			
	Ungerminated Seed		*Pregerminated Seed*		*Ungerminated Seed*		*Pregerminated Seed*	
Russian olive	1	24,200	1	23,300	1	8,300	1	7,400
Honey locust	2	23,300	7	16,700	2	8,000	3	6,350
Desert willow	3	21,800	3	20,900	3	7,700	2	7,100
Siberian elm	4	20,600	4	19,700	4	5,750	7	3,800
Green ash	5	20,000	5	19,700	5	5,750	4	5,300
American elm	6	20,000	6	19,700	18	2,600	11	3,200
Siberian pea	7	20,000	11	12,050	7	5,300	5	4,700
Boxelder	8	19,700		[1]		[1]		[1]
Ponderosa pine	9	19,400	8	16,700	11	4,850	10	3,350
Buffalo-berry	10	17,900	13	11,750	10	4,850	15	2,750
Russian mulberry	11	17,300	2	21,500	8	5,150		[1]
Rocky Mountain red cedar	12	16,700	16	7,850	16	3,800	16	2,750
Hardy catalpa	13	16,700	9	16,100	6	5,450	12	3,200
Osage orange	14	16,100	12	11,900	15	4,100	13	3,200
Eastern red cedar	15	16,100	14	10,700	17	3,800	14	3,200
Choke cherry	16	14,900	17	6,950	14	4,250	9	3,350
Black locust	17	11,000	18	6,900		[1]		[1]
Wild plum	18	9,900	15	9,350	12	4,550	6	4,550
Skunk sumac		[1]		[1]	13	4,400		[1]
Kentucky coffee-tree		[1]	10	13,700	9	5,000	8	3,500

[1] No test available.

Species requiring no pretreatment

Desert willow (*Chilopsis linearis* de Cand.)
Siberian elm (*Ulmus pumila* L.)
American elm (*Ulmus americana* L.)
Siberian pea (*Caragana arborescens* Lam.)
Ponderosa pine (*Pinus ponderosa* Lawson)
Russian mulberry (*Morus alba tatarica* (L.) Loud.)
Hardy catalpa (*Catalpa speciosa* Warder)

The order of alkali tolerance found for the various species is given in Table 1.

The table reveals several points of interest. Sodium carbonate was generally from three to four times more toxic than sodium sulphate. Ungerminated seed required a somewhat higher concentration to prevent germination than what was necessary to inhibit growth of the 5-day-old sprouts of the pregerminated seeds. It was noted that some of the latter failed to elongate the main tip of the hypocotyl in more concentrated solutions but had the ability to form entirely new rootlets.

The order or rank of alkali tolerance by species correlates quite well with empirical observations of older trees and shrubs found in the Great Plains region, except for a few species. It was expected that buffalo berry would rank higher and ponderosa pine considerably lower than they did in the test.

The rating of Russian olive, honey locust, green ash and Siberian elm in the most alkali resistant group ties in very closely with observations made since 1933 in experimental plantings and in the arboretum of a U. S. Forest Service substation near Towner, North Dakota. Here the pH of topsoil is generally around 6.5 but in small localized patches it has a pH of 8.2 to 8.8, thus furnishing an excellent site on which to get contrast in alkali adaptation of various species.

Another test performed on only one species—Rocky Mountain red cedar—showed the alkalis to stand in the following decreasing order of toxicity: (1) sodium bicarbonate; (2) sodium carbonate; (3) magnesium sulphate; (4) sodium chloride; (5) magnesium chloride; and (6) sodium sulphate.

It was observed that small quantities of calcium added in the form of calcium sulphate more than doubled the alkali tolerance.

SUMMARY

Tests were made of the comparative alkali tolerance of ungerminated and presprouted seed of tree and shrub species generally planted in the Great Plains for shelterbelts and farmstead windbreaks. The technique involved placing the seeds in solutions of known concentrations of sodium carbonate and sodium sulphate. The experiment showed there was a wide difference in alkali toler-

ance by species and that the lethal concentration depended not only on the amount of alkali but varied with type of alkali and age of seedling. The overall alkali tolerance rating by species in order of decreasing resistance is as follows:

Most alkali tolerant	*Medium alkali tolerant*	*Least alkali tolerant*
1. Russian olive	8. American elm	15. Osage orange
2. Desert willow	9. Boxelder	16. Skunk sumac
3. Honey locust	10. Kentucky coffee-tree	17. Choke cherry
4. Siberian elm	11. Ponderosa pine	18. Rocky Mountain red cedar
5. Green ash	12. Hardy catalpa	19. Eastern red cedar
6. Russian mulberry	13. Buffalo-berry	20. Black locust
7. Siberian pea	14. Wild plum	

In general this order of rank agrees with empirical field observations of comparative alkali tolerance. Black alkali (sodium carbonate) was generally three to four times more toxic than white alkali (sodium sulphate). Ungerminated seed tolerated more alkali than presprouted seeds with a hypocotyl of one or two centimeters in length and which had been sprouting for about five days. Small quantities of calcium caused a marked increase in the tolerance to alkali. Sodium bicarbonate was found to be highly toxic followed in order by sodium carbonate, magnesium sulphate, sodium chloride, magnesium chloride, and sodium sulphate.

THE TROPICAL ELEMENT IN THE VEGETATION OF SOUTH FLORIDA

WILLIAM S. COOPER
University of Minnesota

THE EFFECT OF THE COPEPOD (*Mytilicola orientalis*) UPON THE OLYMPIA OYSTER (*Ostrea lurida*) *

THERON O. ODLAUG
State Teachers College, Duluth

* Published in Transactions of the American Microscopical Society **65**: (October) 1946.