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Influence of High Salt Levels on the Germination and Growth of Five Potentially Utilizable Plants for Median Turfing in Northern Climates[1]

M. St-Arnaud and G. Vincent[2]
Jardin botanique de Montréal,
4101 Sherbrooke Street E.,
Montreal, Quebec, Canada H1X 2B2

Abstract

We evaluated the germination and growth of *Coronilla varia* (crown vetch), *Lotus corniculatus* (birdsfoot trefoil), *Medicago lupulina* (black medic), *Kochia scoparia* (kochia) and *Polygonum aviculare* (prostrate knotweed) at different NaCl concentrations. No reduction of germination was observed in the five species studied for all concentrations of NaCl. High concentrations of NaCl in the soil adversely affected the growth of *L. corniculatus* and *M. lupulina*, but not of the other species. For *P. aviculare*, germination and growth was better with higher salt concentrations.

Index words: Salinity, plant growth, turf

Species used in this study: *Coronilla varia, Lotus corniculatus, Medicago lupulina, Kochia scoparia, Polygonum aviculare,* crown vetch, birdsfoot trefoil, black medic, kochia, prostrate knotweed.

Introduction

Numerous studies have been conducted on the effects of de-icing salt on road side vegetation (3, 4, 6). However, growth problems associated with salinity in plants used on road medians in northern climates have not been well studied.

During winter months, medians regularly receive surface water from adjacent streets, which increase the NaCl level of the soil and often results in levels that are injurious to plants. Electrical conductivity (EC) values in excess of 100 mS/m (soil/water ratio, 1:2) are considered restrictive to the germination and growth of most plant species (7). Table I lists EC values measured on various road medians in Montreal during spring of 1984. Although salinity can be very high in winter, usually a gradual decrease is observed during spring because of leaching, without any cumulative accumulation over the years. However, in some cases salinity remains high enough to injure the vegetation during the growing season. There are more than 110 km (68 miles) of medians covering an area of approximately 34 ha (84 ac) in Montreal; the areas involved are therefore considerable. When built, these medians were turfed with grasses, which are known for their tolerance to high salinity, gradually disappear and are replaced by forbs, such as *Ambrosia artemisiifolia* (common ragweed), *Chenopodium album* (lamb's quarters), *Kochia scoparia* (kochia), *Lepidium densiflorum* (common peppergrass), *Polygonum aviculare* (prostrate knotweed), *Taraxacum officinale* (dandelion) and others. However, the medians where these species have become dominant rarely show a vegetation cover exceeding 70%.

We evaluated the germination and growth of *Kochia scoparia*, *Medicago lupulina* (black medic) and *Polygonum aviculare*, three species which are sometimes found on median, and two species commonly used as ground covers, *Coronilla varia* (crown vetch) and *Lotus corniculatus* (birdsfoot trefoil). All those species have a decumbent stem, a factor to consider in the maintenance of medians except for *K. scoparia* which tends to have the same growth habit after mowing.

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[2]Botanists, Montreal Botanical Garden, Montreal, Canada.

Table 1. Electrical conductivity measured of soils from eight street medians within city of Montreal.

Median	Soil texture	Electrical conductivity^z (mS/m)			
		84-4-4	84-4-11	84-4-18	84-4-25
1	Silty clay	132	47	44	35
2	Clay loam	134	120	41	39
3	Sandy clay loam	52	40	30	29
4	Clay loam	111	81	40	39
5	Clay loam	1050	240	200	220
6	Loam	175	—	—	—
7	Silty clay loam	190	140	115	120
8	Sandy clay loam	79	—	—	—

[z]Each measurement comes from two samples (10 cm or 4 in depth), from opposite side of the median at 50 cm (20 in) distance from the edge, mixed together after sieving. Electrical conductivity is measured from a ratio 1:2 soil/water suspension; —: data not available.

Materials and Methods

Seeds of *K. scoparia*, *M. lupulina* and *P. aviculare* were harvested in 1983 on wild plants growing on a vacant lot in Montreal. They were air-dried on laboratory counter for five days and stored in air tight glass bottles at 20°C (68°F) until germination tests. Scarified seeds of *L. corniculatus* 'Leo' and *C. varia* 'Penngift' were obtained from a seed distributor. Soil texture was determined with a hydrometer after drying and sieving (2 mm or 0.08 in) (7).

Germination Tests. Seeds were placed in Petri dishes (100 × 15 mm) on two layers of filter paper. Four replicates of 50 seeds for each species were used under each of six different salinity regimes, 0 (deionized water), 50, 100, 150, 200 and 250 mS/m, obtained by dissolving respectively 0, 260, 550, 843, 1125 and 1395 mg/liter NaCl in deionized water at 23°C (73.4°F). Filter papers were imbibed by adding 5 ml of the saline solution and Petri dishes were sealed with parafilm to prevent evaporation.

Germinated seeds were counted and removed at two day intervals during 20 days. Germination was defined as growing of the radicle (4 mm or 0.16 in) out of integuments (5). The experiment was conducted in open daylight but out of direct sunshine at room temperature (23 ± 2°C or 73.4 ± 3.6°F). The experimental design consisted of a randomized complete-block with four replications. Germination percentages were compared with the Wilks probability ratio test followed by a multiple comparison test (10).

Growth. Experiment was conducted in a greenhouse with day-night alternating thermoperiod and photoperiod of respectively 23–18 ± 3°C (73.4–64.4 ± 5.4°F) and 16–8 ± 2 hrs, light intensity up to 95000 lux. No attempt was made to control relative humidity. The substrate was a mixture of silt loam, perlite and sand (equal parts by vol) with a pH of 6.5. No fertilizers were added to the substrate in order to simulate median conditions. Plants were grown in 52 × 26 × 6 cm (20.5 × 10.2 × 2.4 in) plastic containers, filled with 5 kg (11 lb) of dry substrate. Just before sowing, the seeds of *C. varia* and *L. corniculatus* were mixed with appropriate *Rhizobium* inoculant. Then, seeds were disposed uniformly on top of the substrate and covered with fine grade perlite. The initial EC of the substrate was 30 mS/m (soil/water ratio 1:2; 7). Sodium chloride solutions were sprayed uniformly at a rate of 2.5 l (0.66 gal)/container, in such a way to imbibe the substrate completely but without any loss of solution by drain holes. The solution concentrations were adjusted from 1.78×10^{-3}M to 2.58×10^{-2}M, in order to obtain EC of substrates ranging from 50 to 300 mS/m. This represents the range of electrical conductivities (EC) measured the previous spring, in median strips exposed to de-icing salt. The check sample contained only the initial substrate. Subsequent waterings were made every day with deionized water using the same volume for all treatments and without leaching salts. The experimental design was a randomized complete block without replication. For each treatment, 10 plants were randomly chosen for growth measurements. The distance between the collar and apex was measured on a weekly basis for 10 or 11 weeks. At the end of that period, the plants were harvested, dried at 100°C (212°F) for 24 hrs and the dry weight of aerial portions recorded. Growth statistics (dry weights, lengths) were compared through variance and linear regressions analyses (8).

Results and Discussion

Salt concentrations gradients did not seem to influence germination in a significant way, although the 5 species studied responded differently. After 23 days, *L. corniculatus*, *C. varia* and *M. lupulina* do not show any significant difference in terms of percentage of germination according to salinity (Fig. 1c, d, e). We observed a significant increase in germination of *P. aviculare* when the seeds are placed in strongly saline solutions and for all NaCl concentrations studied, maximum germination is reached on the 6th day (Fig. 1b). Finally, *K. scoparia* seeds present a significant increase in germination when they are placed in a NaCl solution of 50 mS/m (Fig. 1a).

The growth response of the five species differed according to the salinity of the substrate. The presence of sodium chloride does not have a negative effect on the growth of *K. scoparia*, *P. aviculare* and *C. varia* (Fig. 2a, b, d and Table 2). Moreover, for *P. aviculare*, the mean dry weight of the aerial portions of the plants grown on the 235 mS/m substrate was significantly higher than that of the plants grown on the 25 mS/m substrate. Therefore, the growth of *P. aviculare* appeared to improve with the presence of NaCl.

The mean length of the stems of *L. corniculatus* decreased significantly for the highest salinity considered. Concerning the mean dry weight, for an EC range varying between 21 and 190 mS/m, no difference was observed (Fig. 2c and Table 2). However, highly significant negative correlation coefficients were found between length (R: −0.527) and dry weight (R: −0.347) variables and the EC of the substrate. These negative correlation coefficients illustrate a possible detrimental effect of salinity on the growth of *L. corniculatus*.

The growth of *M. lupulina* was also clearly affected by the presence of NaCl in the substrate (Fig. 2e and Table 2), although the effect is progressive and intensifies two months after sowing. A highly significant negative correlation was observed between the mean length (R: −0.444) and mean dry weight (R: −0.548) of the plants after 81 days of growth and the EC of the substrate. Moreover, the mean length and dry weight of the plants were significantly lower for the 165

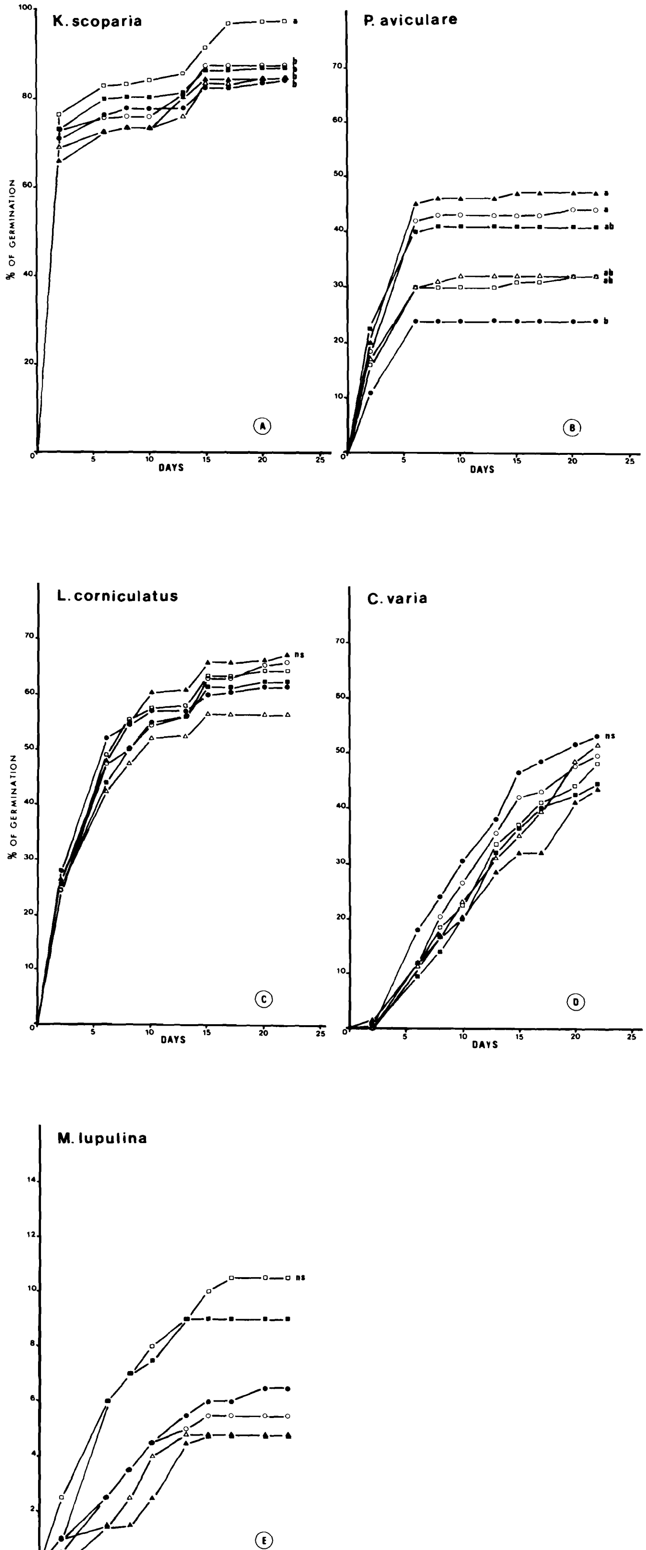

Fig. 1. Percentage of germinated seeds in relation to time in NaCl solutions of different EC; a) *Kochia scoparia*, b) *Polygonum aviculare*, c) *Lotus corniculatus*, d) *Coronilla varia* and e) *Medicago lupulina*. Legend (EC of solution in mS/m); ●: 0, □: 50, ■: 100, △: 150, ▲: 200 and ○: 250. After 23 days germination, percentage of germinated seeds followed by the same letter are not significantly different at the 5% level using Scheffe multiple comparison test. Ns = not significant.

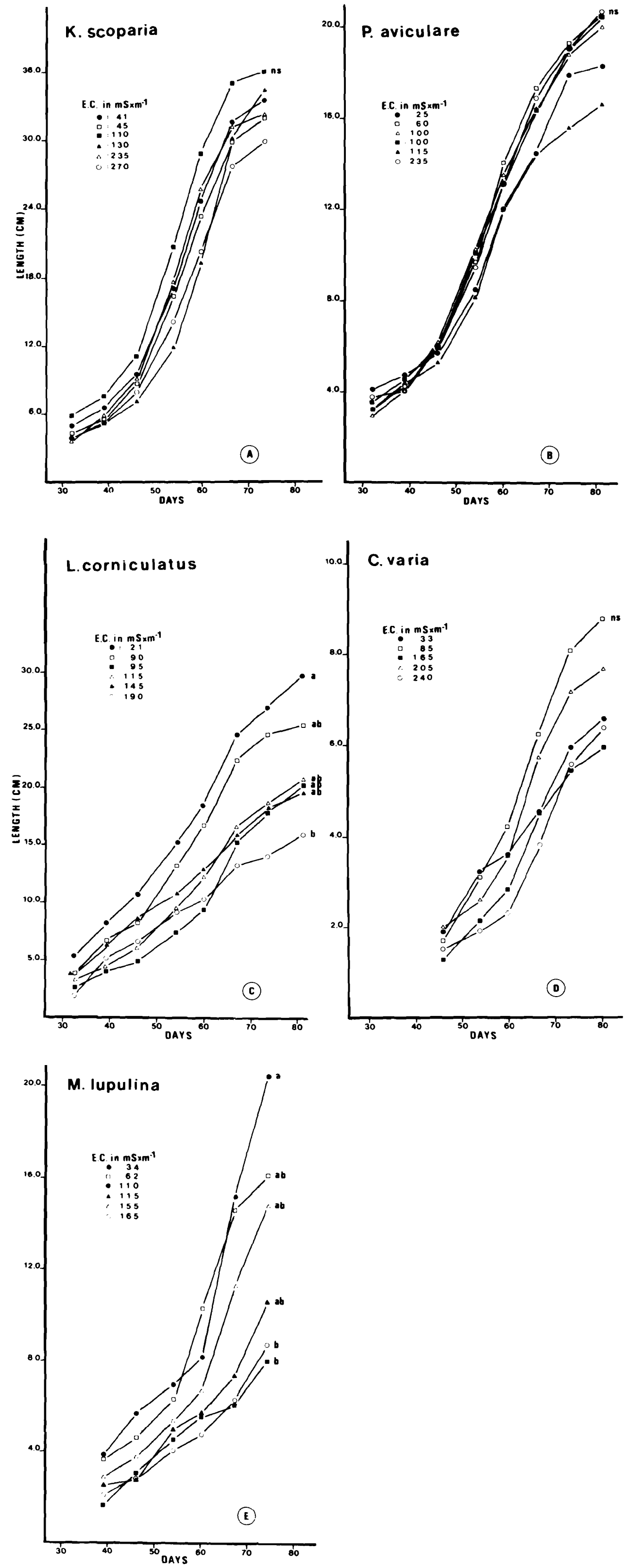

Fig. 2. Mean length of plants in relation to time on substrates of different EC (soil/water ratio of 1:2) representing NaCl content; a) *Kochia scoparia*, b) *Polygonum aviculare*, c) *Lotus corniculatus*, d) *Coronilla varia* and e) *Medicago lupulina*. At the end of the growing time, mean length of stem followed by the same letter are not significantly different at the 5% level using Scheffe multiple comparison test. NS = not significant.

Table 2. **Mean dry weight of aerial parts of *Kochia scoparia* and *Medicago lupulina* after 74 days growth and *Polygonum aviculare*, *Lotus corniculatus* and *Coronilla varia* after 81 days growth on substrate of increasing electrical conductivity.**

M. lupulina		*K. scoparia*		*P. aviculare*		*L. corniculatus*		*C. varia*	
EC[z]	dw[y]	EC	dw	EC	dw	EC	dw	EC	dw
34	0.834[a]	41	0.461[a]	25	0.155[b]	21	0.202[a]	33	0.077[a]
62	0.597[ab]	45	0.438[a]	60	0.259[ab]	90	0.201[a]	85	0.097[a]
110	0.160[ab]	110	0.444[a]	100	0.236[ab]	95	0.136[a]	165	0.070[a]
115	0.213[ab]	130	0.441[a]	100	0.240[ab]	115	0.167[a]	205	0.099[a]
155	0.347[ab]	235	0.494[a]	115	0.167[ab]	145	0.125[a]	240	0.051[a]
165	0.106[b]	270	0.421[a]	235	0.281[a]	190	0.067[a]	—	—

[z]Electrical conductivity of substrate in mS/m (1:2, soil/water).

[y]Dry weight of aerial parts in milligrams; mean values in a column followed by the same letter are not significantly different at the 5% level using Scheffe multiple comparison test.

mS/m substrate as compared with the check sample. *M. lupulina* is therefore very sensitive to the presence of NaCl.

Among the species studied, three are tolerant to high levels of salt: *K. scoparia*, *P. aviculare* and *C. varia*. *C. varia* is a perennial, therefore its survival does not exclusively depend on germination. However, its growth recovery would occur early in spring when the concentration of NaCl in the roadside median is still high. The use of *C. varia* along roadsides in the northeastern U.S. has been proven successful in contrast to highly-varying results in Ontario under similar conditions (1).

The two other species are annuals. The survival of an annual is directly dependent on the success of germination and it has been shown that seedlings are much more sensitive to salts than adult plants (6). However germination can occur later in spring when NaCl concentration is lower due to the washing out process observed in the median strips. Our tests on *P. aviculare* have shown an increase in productivity linked to an increase in the salinity of the substrate; such phenomenon had already been noticed in some species (9, 12). This, combined with the positive effect of NaCl on the germination of that plant, makes it an interesting prospect for vegetating the more exposed medians. Although *K. scoparia* and *P. aviculare* are annual species, their high germination rate and the great quantity of seeds that a single plant may produce, make them useful species as plant cover on medians. In addition, as in the case of *C. varia*, both species offer an appropriate form of growth with respect to maintenance (frequency of mowings). However, *K. scoparia* is known to have allelochemical properties and its own growth or the growth of other plants can be significantly reduced after some years (2). Nevertheless, this species is naturally well established on some medians.

Finally, it must be noted that our experimental conditions do not necessarily reflect the various situations which may exist on medians: excessive drainage, compaction, soil texture, etc. However, our study has determined that *C. varia*, *K. scoparia* and *P. aviculare* offer characteristics that make them suitable for use in environments with salinity related restrictions.

Significance to the Nursery Industry

Since there seems to be no valid alternative to the use of de-icing salt, solutions lie in the search for species or varieties showing resistance to higher NaCl levels in the soil. This study shows that the use of dicot species can be useful. In that sense, it is interesting to note that germination and growth of *P. aviculare* is promoted in relatively high salt conditions. In addition, some of these species present an advantage over grasses in mowing frequency requirements and trampling resistance. Although other dicot species could have the same characteristics, our study of five selected species has shown that their use should be considered for median turfing in some situations.

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