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Zinc Tolerance in Wavy Hairgrass, *Deschampsia flexuosa,* Growing in Acid Soil Beneath a Corroding Galvanized Electrical Transmission Tower

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A population of Wavy Hairgrass growing in Zn-contaminated, acid soil beneath a corroding galvanized electrical transmission tower on the Precambrian Shield near Kaladar, Ontario, Canada, exhibited tolerance to Zn in a hydroponic root growth experiment. The selection of tolerant individuals of this species and subsequent establishment of the population must have occurred relatively rapidly since the tower was 32 years old when plants were collected for Zn tolerance testing.

Key Words: Wavy Hairgrass, *Deschampsia flexuosa*, zinc, tolerance, galvanized electrical transmission towers, ecotype, Ontario.

The Wavy Hairgrass, *Deschampsia flexuosa* (L.) Trin, is an abundant species of dry, acidic habitats in parts of the Precambrian Shield (Dore and McNeill 1980). Jones and Burgess (1984) reported that in 1980 isolated tufts of this grass were the only plants growing in Zn-contaminated, acid soil (pH = 5.1 $\pm$ 0.1, n = 3) in a natural drainage channel leading from a corroding electrical transmission tower constructed on a granitic outcrop of the Precambrian Shield, near Kaladar in southern Ontario, Canada. They reported concentrations of 1535 $\pm$ 129 μg of Zn per g dry weight (n = 4) in *D. flexuosa* shoots from the drainage channel, whereas 13 m upslope from the tower, shoot Zn concentrations were ca.10 times lower (159 $\pm$ 15 μg^{-1}). Tolerance to high soil-Zn has been reported in a number of plant populations (for example, Antonovics et al. 1971; Cox and Hutchinson 1980; Bradshaw and McNeilly 1981; Al-Hiyaly et al. 1990). Based on these reports, it is suggested that, as the concentration of Zn in the soils beneath the Kaladar tower increased due to corrosion of the protective Zn coating on the tower, selection may have given rise a population of *D. flexuosa* tolerant to Zn. This note reports the results of a hydroponic test for tolerance to Zn by roots of tillers of *D. flexuosa* collected under and around the same Kaladar tower.

Materials and Methods

The transmission tower is located on the south side of the Trans Canada Highway, near Kaladar, Ontario, Canada at 44° 33'N, 77° 15'W. Small tufts (30), of *D. flexuosa*, each consisting of several tillers, were collected randomly under the tower and within 5 m of the tower in small channels which carried run-off from the corroding lattice structure. A further 30 tufts were collected 60 m south-west of the tower, in the up-wind direction of the generally prevailing wind. At such a distance it is unlikely that the soil is being contaminated with Zn from the tower.

Soil was shaken from the roots of the tufts for later analysis and individual tufts were rinsed thoroughly with tap water. The tufts were placed in quarter-strength Hoagland's solution (Hoagland and Arnon 1950) for two months of growth. Then healthy individual tillers were removed from respective tufts for the hydroponic culture root-growth tolerance test described in Al-Hiyaly et al. (1988). Tillers, replicated two to four times, depending on the size of the tufts from which they were collected, were selected to determine root growth in quarter-strength Hoagland's solution (Hoagland and Arnon 1950) containing Zn (as zinc sulphate) selected from the following range of concentrations, 0, 2.5, 5.0 or 7.5 μg Zn l^{-1}, giving solutions of pH 6.0, 5.8, 5.6 and 5.5, respectively). The roots of each tiller, clipped to 4-cm length, were inserted into a 5-cm long plastic drinking straw for support. Individual straws were inserted in Styrofoam sheet (6 cm × 6 cm and 2 cm thick) so that the roots were immersed in 250 ml of the respective test solution contained in an aluminium-wrapped glass jar. Jars, with replicates arranged in a randomised block design, were placed beneath Gro-lux lamps with a photoperiod of 14 h. The ambient temperature during the test was 22 ± 3°C. Solutions were changed every 3 to 4 days and after 4 weeks, the longest root of each tiller was measured and tolerance indices were determined for each Zn concentration using the method of Jowett (1964):

$$\text{Tolerance index} = \frac{\text{Mean length of longest root in the solution with Zn}}{\text{Mean length of longest root in the solution without Zn}}$$

Total Zn in oven-dried (110°C), ground (100 mesh) soil was determined by pre-digesting, at low heat, the soil with 3 ml of concentrated HNO_3 in glass tubes in an aluminium heating block (Allen 1974). Then 3 ml of aqua regia were added and the digestion continued for a further 2 h at increased heat. The cooled digest was brought to 100 ml with N HCl and filtered for Zn determination by atomic absorption spectrophotometry (AAS). Analysis of three replicates of a river sediment sample (NBS Reference Material 1645, United States Department of Commerce) gave concentrations of Zn that were in the certified range of 1720 ± 169 μg g^{-1}. Available Zn was determined by extracting 2 g of air-dried soil with two consecutive lots of 20 ml 0.1 N HCl (Baker and Amacher 1982), each time shaking the mixture for 5 min and filtering. The combined filtrate was brought to 50 ml with 0.1 N HCl for analysis by AAS. Soil pH was determined for a 1:1 mixture of fresh soil and de-ionised water with a glass calomel electrode (Jackson 1958). Finely-ground, oven-dried soil was muffled at 550°C for 3 h to determine loss on ignition as a measure of organic content.

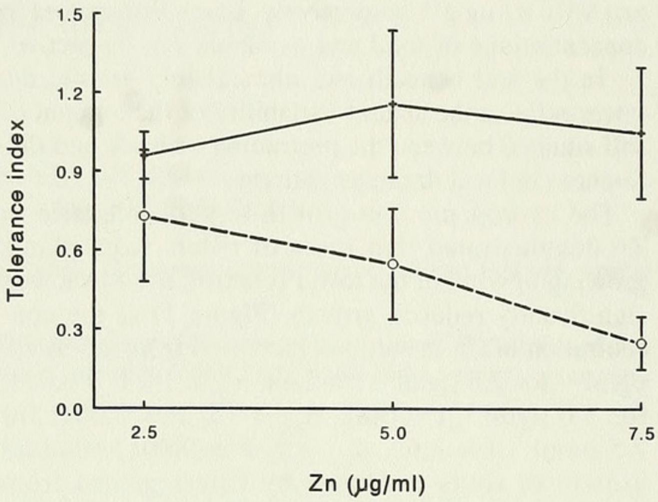

FIGURE 1. Tolerance indices for roots of *Deschampsia flexuosa* collected beneath and 60 m from a corroding galvanized electrical transmission tower. The vertical bar represents the standard deviation for respective mean data points.

Results and Discussion

The soils under the tower and 60 m upwind from the tower had organic contents of 25.3 ± 20.5 (± SD) and 20.4 ± 11.4 % dry weight, respectively. The pH of the soils from the two sites was similar, being in the range 5.5 to 6.0. A t-test indicated that there were, however, significant differences ($P \leq 0.05$) between the concentrations of total and extractable Zn, respectively, in soil shaken from roots of samples of the *D. flexuosa* populations collected from the two sites. The total Zn in soil shaken from plants growing 60 m upwind of the tower was 10 ± 5 μg g^{-1} and the extractable Zn was less than 0.05 μg g^{-1}, whereas the total and extractable Zn in soil shaken from roots of plants growing under and close to the tower were considerably higher at 5851 ± 7621 μg g^{-1}

and 95 + 82 μg g^{-1}, respectively. Large differences in concentrations of total and available Zn, respectively, in the soil beneath and immediately around the tower reflects the spatial variability of the amount of soil situated between the protruding bedrock and differences in local drainage patterns.

The hydroponic root-growth test for tolerance to Zn demonstrated that roots of tillers from plants growing upwind of the tower (control, n = 8) showed significantly reduced growth (Figure 1) as the concentration of Zn in solution increased from 2.5 to 7.5 μgml^{-1} (for 2.5 μgml^{-1}, t = 2.44, n_{Zn} = 13, P = 0.024; for 5.0 μgml^{-1}, t = 5.82, n_{Zn} = 15, P = 0.001; for 7.5 μgml^{-1}, t = 8.69, n_{Zn} = 9, P = 0.001) whereas growth of roots produced by tillers grown from plants collected beneath the tower was unaffected by the range of Zn concentrations used in this test. These data indicate that high available Zn in the acidic soil below the corroding tower has lead to selection for a tolerant ecotype of *D. flexuosa*. Furthermore, the fact that the tower was constructed in 1958, suggests that selection for Zn tolerance by *D. flexuosa* occurred during the following 32-year period and possibly earlier since high Zn concentrations had already been found in shoots of *D. flexuosa* growing beneath the tower (Jones and Burgess 1984).

Even though *D. flexuosa* plants were collected from just one tower, it is likely that other tolerant populations of this species are growing beneath other corroding towers on the Canadian Shield, particularly as this is a widespread species (Dore and McNeill 1980) and *D. flexuosa* is often present beneath or near to towers where general floristic biodiversity is reduced. In Europe, tolerance to manganese (Mahmoud and Grime 1977), lead (Hoiland and Oftedal 1980), and aluminium (Hackett 1965) has been shown in *D. flexuosa*. However, despite the fact that *D. flexuosa* is colonizing formerly barren metal contaminated soils at Sudbury, Ontario) 20 years after smelter closure (Winterhalder 1996), Archambault (1989) concluded that populations growing on metal-contaminated Sudbury soils were not more metal tolerant than control populations.

This study is the first one reporting Zn tolerance due to galvanized transmission towers in Canada. Transmission lines may provide a useful source of Zn-tolerant plants for revegetation of Zn-contaminated sites.

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