Research Note

PRELIMINARY EVALUATION OF A LIVING WILLOW (*SALIX* SPP.) SOUND BARRIER ALONG A HIGHWAY IN QUÉBEC, CANADA

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Urban populations are becoming more concerned about air and noise pollution caused by motor vehicle traffic and are demanding solutions. Conventional concrete walls built to mitigate the effects generated by motor vehicle traffic have a negative impact on the urban landscape and quality of life. During the last decades, private companies in diverse countries, notably in Germany and the United Kingdom, have developed a new technology based on the use of living stems to build green walls as noise barriers. In Canada, a private company, The Living Wall Inc., owns a patent on living noise barriers (Freitag 2001) and promotes their use in the province of Ontario. However, to our knowledge, no serious scientific study has been conducted to evaluate the potential and the limits of these structures, especially in regions characterized by rigorous winters.

The principle of construction of living walls is based on the use stems of willows (*Salix* spp.), plants characterized by very high growth and photosynthetic rates (Cannell et al. 1987, 1988; Labrecque et al. 1993). Willow living walls can be established quickly and require easily accessible organic materials (plants, soil, and wood). They are aesthetic, are green, and contribute to the improvement of the landscape in urban areas. Their organic porous structure (plants and soil) might be more effective than concrete walls in attenuating noise. In addition, these structures can have a positive impact on carbon sequestration and on the diversity of fauna habitats, particularly birds.

The objectives of this study were to verify whether living walls can be established and grown in the climatic conditions of Québec province (eastern Canada).

MATERIALS AND METHODS

Experimental Site

The living wall set up for this study was established in the city of Saint Bruno, located about 15 km (9 mi) southeast of the city of Montréal, Québec, Canada. The climate of the area is continental, characterized by cold, snowy winters and hot, humid summers. The annual average temperature is 6.4°C (43.5°F), and annual average precipitation is 954 mm (37.5 in.) (Ministère de l'Environnement du Québec 1991).

The experimental wall, 30 m (98 ft) long, was established on a marginal north site of Highway 116, in a residential sector of Saint Bruno. It was oriented parallel to the road on an east–west axis.

Plant Material

A European basket willow clone (*Salix viminalis* L.), identified by the Québec Ministry of Forestry as clone 5027, was used in this experiment. This clone has been studied for many years and is known to be very productive in culture in southern Québec (Labrecque et al. 1993, 1994). Two thousand willow stems were used. The stems harvested were 4 years old but were developed on 7-year-old roots. Straight, nonramified stems with a minimal length of 3.5 m (11.5 ft) and a diameter at the base between 4 and 6 cm (1.6 and 2.3 in.) were cut during March 2002 (before budbreak) about 10 cm (4 in.) above ground level. Following their harvesting, stems were packed and stored in the field under a white plastic cover for 1 month until their transportation to the site of construction. During outdoor storage, temperatures stayed around 0°C (32°F), and only a very limited number of the stems started to bud.

Construction of the Wall

The construction was set up in April, as soon as the ground had thawed out. Following transport to the construction site, stems were quickly assembled tightly in the wooden frame and installed upright in two 1 m (3.3 ft) deep trenches set 1.2 m (4 ft) apart. The two willow walls were solidly held together by wood pieces and steel rods (Figures 1 and 2). A permeable, 2.5 m (8.2 ft) wide, thin geotextile was fastened inside over the entire length of the wall. The trenches were filled with a sandy-textured soil. A tractor equipped with a front loader was used to fill the space (with the same soil) between the two walls up to a height of 2.5 m (8.2 ft). At the end, a perforated irrigation hose connected to the municipal aqueduct was fixed at the base of the stems (20 cm [8 in.] above ground level) throughout the two sides of the wall. Once finished, the wall was 30 m (98 ft) long, 1.2 m (4 ft) wide, and 2.5 m (8.2 ft) high. More details about the construction of the wall are given in the patent description (Freitag 2001).

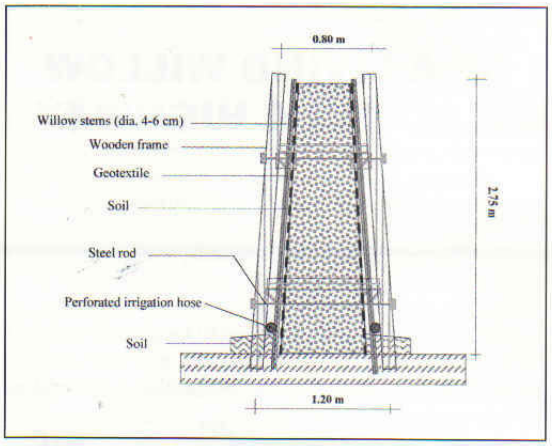

Figure 1. Schematic transversal section of the living wall.

Figure 2. Stems are assembled tightly in a wooden frame and installed upright in two trenches set 1.2 m (4 ft). apart.

Maintenance Work

Once the wall was completed, the willows stems were watered thoroughly at the base. Abundant rainfall and air temperatures lower than normal recorded during the following weeks were favorable to stem and root development. From July to the end of September, an automatic irrigation system was installed and adjusted to provide a daily dose water of six 6 L (1.6 gal) per linear meter. Half of this dose was applied in the morning, the other half in the evening.

At the end of May, the soil at the base of the wall was fertilized using 6 kg (13.2 lb) of sheep manure per linear meter. In July, an additional dose of 15-6-12 chemical fertilizer (0.04 kg/m [0.09 lb]) was applied and mixed to the soil.

Measurements and Sampling

Following the construction of the wall, an experimental design was set up. Each side of the wall (north and south sides) was split in four plots 6.25 m (20.5 ft) long and 2.5 m (8.2 ft) high to compare the growth performance of branches during the establishment year of the wall.

At the end of the first growing season, six stems per plot were randomly chosen. The height and the diameter at the base of each new branch developed from the main stem were measured according to their insertion position (from the soil level to 1 m [3.3 ft] and from 1 m to 2.5 m [8.2 ft]). Branches and leaves were collected separately and oven-dried at 70°C (158°F) for 24 h, to evaluate the dry biomass. The number of new branches produced per linear meter of wall was also counted. Analyses of variance (ANOVA) were performed on growth and productivity data (SAS 1989).

Root development was estimated at the end of the growing season by digging 1 m^3 (35 ft^3) pit (1 × 1 × 1) at the base of the stems.

RESULTS AND DISCUSSION

Growth Performance

Three weeks following the construction of the wall, opening buds and expanding shoots were observed at first on the south of the wall but, soon after, the stems on the north side also started to grow. About 8 weeks after establishment, the wall was completely green (Figure 3). Table 1 presents the characteristics measured on stems of each side of the wall at the end of the first growing season. The statistical analysis (ANOVA) of the data collected did not highlight any significant differences between the parameters measured on both sides of the wall. The average number of new branches developing on stems varied between 5.54 and 6.45, and they were almost equally distributed along the entire stem. At the end of summer, the newly developed branches reached almost 2 m (6.6 ft) in height, forming a wall 4.5 m (15 ft) high. The dry biomass of the newly developed branches was 2.17 kg (4.8 lb) and 1.93 kg (4.3 lb) per linear meter on the south and the north sides, respectively.

At the end of the season, it was noted that the majority of the roots developed in the superficial layer of the soil from 0 to 20 cm (0 to 8 in.) and were about 20 to 30 cm (8 to 12 in.) long. However, some exceeded 1 m (3.3 ft). The total number of roots decreased with the depth. These results, therefore, indicate that the irrigation and fertilization regimes used were adequate to allow a good development and growth of new branches and roots.

Susceptibility to Winter Conditions, Insects, and Diseases

The first winter following the establishment of the wall was particularly cold. Temperatures for January to March 2003 were below normal because most of Québec province was

Table 1. Growth performance of willows (number, diameter, length, and dry mass of branches) at the end of the first season of growth.

Parameter measured	Unit	North side	South side
No. of branches up to 1 m long		3.50 a*	2.63 a
No. of branches between 1 and 2.5 m long		2.96 a	2.91 a
Total no. of branches up to 2.5 m long		6.46 a	5.54 a
Diameter of branches up to 1 m long	mm	11.17 a	10.4 a
Diameter of branches between 1 and 2.5 m long	mm	10.45 a	11.27 a
Length of branches (up to 1 m)	m	1.92 a	1.90 a
Length of branches (1–2.5 m)	m	1.62 a	1.84 a
Dry mass of branches per linear meter of wall	kg	1.93 a	2.17 a
Dry mass of leaves per linear meter of wall	kg	0.65 a	0.66 a

*On the same line, means with the same letter are not significantly different at $P < 0.05$.

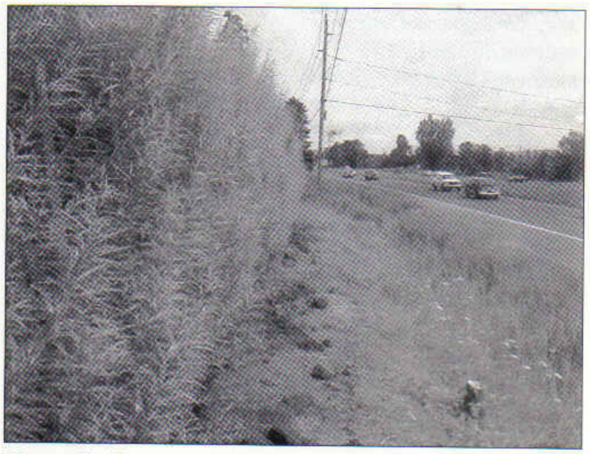

Figure 3. About 8 weeks after establishment, the wall was completely green.

affected during several days by an arctic air mass. In January and up to mid-February, the overnight lows generally varied from –20°C to –30°C (–4°F to –22°F) (CRIACC 2004). In spite of this, no freeze damage was observed in spring. In the same way, the branches did not seem to be affected by the spraying of de-icing salt, though a thick, salty, whitish deposit was observed on their surface during the winter. The survival rate of the stems in the following spring was nearly 100%. No significant attack by insects or pathogenic fungi was observed throughout the course of the study.

The acoustic measurements necessary for the evaluation of anti-noise characteristics of the wall were not performed in this study because this experimental wall was not long enough to validate such measurements. However, tests carried out in Germany on a similar type of living wall showed that sound reduction properties were comparable to any type of wall that exists at present (metal, concrete, etc.). Thus, the value of soundproofing measured on these living walls was 31 dB (ETS 2004). Compared with U.S. standards for noise level measured in the environment, this value is considered very little (U.S. Department of Housing and Urban Development 1985).

CONCLUSIONS

The encouraging results obtained in this study show that living willow sound barriers are relatively simple to build and offer an effective and ecological alternative to conventional noise barriers used in urban areas.

At the end of the first season, the willow stems were very well rooted and developed a large number of branches that covered the entire surface of the wall. The fertilization and irrigation regimes were adequate because they stimulated vigorous growth of the plants throughout the season. No pest control was necessary; the willows were in good health without any sign of insect or disease attack. Branch survival following the rigorous winter was nearly 100%. No injuries caused by frost or salt spray were observed.

In spite of these encouraging preliminary results, further research is needed to evaluate the sustainability and the longevity of these walls in Québec or in regions with similar climatic conditions.

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