

Potential Use of Containerised Willow Transplants in the Falkland Islands

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Abstract: In November 2002, 5 *Salix* spp. clones were brought from the UK to the Falkland Islands. The objectives were: 1) to determine if transfer from the Northern to the Southern Hemisphere would be successful; 2) to produce containerised willow with strong root systems and top growth that would establish and provide shelter more rapidly; and 3) investigate whether cuttings would grow better if grown in containers rather than outplanted directly into the soil as nonrooted cuttings.

Preliminary results (3-month growth) appear to indicate that the containerisation of willows significantly improves shoot and root growth. Of the 5 species evaluated, *Salix viminalis* and *Salix x dasyclados* have produced willow plants with superior quality and vigour compared with the rest of the varieties. These varieties have also shown continued accelerated growth (length and number of primary shoots) between January and March 2003 in a controlled environment.

In early September 2003, the willows will be outplanted out on a commercial farm on cultivated land to test the impact of plant quality on subsequent field performance—survival, growth, disease status, and stability. This will provide information on species selection, potential use, and economic viability of willows in the Falklands.

Keywords: willow, clones, containerisation, Falkland Islands, *Salix*, utilisation

Introduction

The Falkland Islands are an archipelago in the South Atlantic Ocean (latitudes 51° 00' and 52° 30' south; longitude 57° 40' and 61° 30' west) approximately 450 km (280 mi) northeast of Tierra del Fuego. There are approximately 2,500 residents, 10% of whom live in rural areas. Topography is mainly rolling hills and plains, and the islands are naturally treeless.

Most of the 90 farms are family units of approximately 13,500 ha (33,360 ac). Nowadays the economy is based mainly on fishery licensing management and sheep farming for wool, the main economic base of the islands for the past 160 years. At its peak in 1900, there were approximately 800,000 sheep (Kerr 2002).

The climate is maritime, cool and windy. There is a narrow temperature range and the windiest months are October and November, when gusts of over 120 km/hr (75mi/hr) have been recorded. The total annual precipitation level does not exceed

620 mm (24.5 in) and is evenly distributed throughout the year, with ranges between 350 mm (14 in) on west Falkland to 620 mm on east Falkland. Mean sunshine hours are relatively low due to the high frequency of cloud cover.

Since the islands were colonised in 1764, attempts have been made to grow trees mainly for amenity and shelter purposes. These attempts have had varying degrees of success. Some species, such as Monterey cypress and lodgepole pine (*Cupressus macrocarpa* and *Pinus contorta*), have proved to be successful. However, there is still a need for quick growing shelter and to diversify the range of tree species planted on the Falkland Islands (Low 1999; Palmer 2001; Olave 2003).

Willow is one of the fastest and easiest plants to propagate. When willow is inserted into the ground, cuttings root and grow. However, in the Falkland Islands environment, with soil and climatic limitations, this type of establishment has been difficult.

Interest in growing willows for different uses on the Falkland Islands began in 1990. During this period, a number of nonrooted willow cuttings (some from the Northern Hemisphere) were outplanted into a damp sheltered site using species occasionally grown locally for hedging to assess their suitability (McAdam and others 1990). A second attempt with nonrooted cuttings was carried out in 1999, where a wide range of species/varieties of willow from the Northern Hemisphere were tested and outplanted directly into the soil at 4 different sites (Dawson 1999; Olave and others 2002).

Unfortunately, both attempts failed due to poor establishment. Probably the main reasons were prolonged dry weather after outplanting, asynchronous seasonality of the cuttings brought from Northern to Southern Hemisphere, competition mainly from weed and grass vegetation, and inadequate ground preparation (Olave and others 2002).

The overall objectives of this new study are: 1) to investigate whether willow cuttings of 5 different clones would grow better if initially grown in containers rather than outplanted directly into the soil as nonrooted cuttings; and 2) to test whether the seasonality of the growth cycle from Northern to Southern Hemisphere can be broken. Subsequently, the

feasibility of outplanting and the economic and biological tradeoffs in terms of root development and establishment in the Falkland Islands will be determined.

This paper reports followup work on the attempt to introduce willows through the container production of 5 willow clones grown under controlled condition for 3 months. Information on further assessments of their potential under field conditions in the Falkland Islands is also presented.

Material and Methods

Plant Material and Growth Conditions

Healthy cuttings of 25 cm (10 in) in length with a minimum diameter of 8 mm (0.3 in) were collected from woody willow material. Material from 5 different clones (Table 1) was obtained from 1-year-old dormant stems grown outdoors in 2002 at Northern Ireland Horticulture and Plant Breeding Station, Loughgall, Co Armagh, and transported to the Falkland Islands in November 2002. The selection of the 5 clones was based on the following factors: 1) ability to be used as shelterbelt, energy, or bioremediation; 2) suitability for browsing and amenity purposes; and 3) tolerance to acid peat soils with low nutritional status, wind resistance, and dry climate.

Cuttings were stored at -2°C (28.5°F) until early January when half of them were containerised and grown in a greenhouse. Sixty cuttings per clone were planted in 21 (0.5 gal) pots and filled with a commercial medium (Sinclair, SHL Peat-Bark) and sand. Controlled release fertiliser (Scotts, 14N:9P₂O₅:14K₂O, 8 month longevity) was incorporated at 300 g/m³ (0.3 oz/ft³) and irrigated as needed. The experiment was a randomised block design with 5 treatments. Each treatment consisted of 3 replications of 20 cuttings per replication. Day and night temperatures were kept at 15 °C and 9 °C (59 °F and 48 °F), respectively, for 16 weeks.

This experiment will be continued in September 2003, when rooted and nonrooted cuttings will be outplanted on commercial farmland that is already prepared.

Table 1—Willow clones used in the study.

Species	Characteristics
<i>Salix x calodendron</i>	Hybrid between <i>Salix caprea</i> , <i>S. cinerea</i> , and <i>S. viminalis</i> . It has proved to be a very robust variety in trials across the UK, dealing particularly well with poor exposed sites. Not the highest yielding variety, but consistent.
<i>Salix eriocephala x S. exigua</i> 611	Hybrid of Canadian origin that has given good yield in Northern Ireland. More importantly, it has shown no susceptibility to the European strains of rust.
<i>Salix viminalis</i> 78183	Swedish clone and the most widely planted in their biomass programme. The yield is moderate, but the clone has shown consistent results over a wide range of sites.
<i>Salix x hirte</i> 'Reifenweide'	Hybrid with <i>Salix cinerea x S. viminalis x S. aurita</i> . A very robust clone, dealing successfully with poor sites and exposed conditions. The hybrids with <i>S. cinerea</i> do not tend to suffer to the same extent with the rust species <i>Melampsora epitea</i> , but are susceptible to the less problematic <i>M. caprearum</i> .
<i>Salix x dasyclados</i>	Hybrid with the same parentage as <i>Salix x calodendron</i> . It was planted with some success in the Falkland Islands some years ago. Like <i>Salix x calodendron</i> , it is a robust clone. Unlike <i>S. x calodendron</i> , it has a rather spreading, untidy growth habit.

Data and Analysis

During the first week of April 2003, willow plants were taken out of the greenhouse to let them harden off before winter. Length and number of shoots were recorded and 3 samples of each variety from each replicate were destructively harvested for the determination of root and shoot fresh and dry weights. Leaf samples were taken at the same stage and analysed for nitrogen (N), phosphorus (P), and potassium (K) content.

Conventional analysis of variance was used to analyze root and shoot weights, root-to-shoot ratio, and number and length of primary willow shoots.

Soil samples were taken in January 2003 in order to determine the fertility of the substrate where the rooted and nonrooted willow cuttings will be outplanted. The samples were combined to give bulked samples for chemical analysis and pH.

Results and Discussion

In this first stage of the study, 5 clones of willow cuttings were containerised, grown in a greenhouse for 3 months, and measured at the end of that period. *Salix viminalis* and *Salix x dasyclados* emerged as the overall leaders in terms of primary shoot production, length of shoot, and morphological attributes (Tables 2 and 3). However, these preliminary results do not provide information on their field performance. Future elements of the programme will involve assessment of parameters related to outplanting, management, and usage.

Table 2—Average length and number of primary shoots of willows after 3 months growing in the greenhouse in the Falkland Islands.

Willow clones	Shoots	Primary shoot
	number	cm
<i>Salix x calodendron</i>	4.0 a	41 a
<i>Salix eriocephala</i> x <i>S. exigua</i> 611	4.0 a	54 b
<i>Salix viminalis</i>	6.0 b	41 a
<i>Salix x hirtei</i> 'Reifenweide'	4.5 a	45 a
<i>Salix x dasyclados</i>	5.0 a	56 b

Values in one column followed by the same letter are not significantly different at $P > 0.05$.

Table 3—Average dry and fresh weight of shoot and root of 5 willow clones after 3 months growing in a greenhouse in the Falkland Islands.

Willow clones	Root fresh weight	Root dry weight	Shoot fresh weight	Shoot dry weight	Root-to-shoot ratio
	g				
<i>Salix x calodendron</i>	19 a	3 a	37 a	12 a	0.27 a
<i>Salix eriocephala</i> x <i>S. exigua</i> 611	18 a	3 a	44 a	15 a	.22 a
<i>Salix viminalis</i>	28 b	7 b	46 b	17 b	.40 b
<i>Salix x hirtei</i> 'Reifenweide'	19 a	4 a	39 a	14 a	.30 a
<i>Salix x dasyclados</i>	23 a	4 a	42 a	14 a	.28 a

Values in one column followed by the same letter are not significantly different at $P > 0.05$.

Number and length of willow primary shoots are important components of growth form and affect their potential use (Table 2). *Salix viminalis* and *Salix x dasyclados* show a slight tendency to produce greater numbers and length of shoots, respectively, than the other cultivars. These measurements, plus the field response, will help to evaluate which clones will be more suitable on the Falkland Islands environment if characteristics such as density or height are seen as desirable.

Measurements of root and shoot dry mass of the plants after 3 months growing in the greenhouse (to be linked with survival potential and plant growth following outplanting) are shown in Table 3. Analysis of variance of the 5 clones showed dry and fresh weight of roots and shoots of *Salix viminalis* were significantly greater than other cultivars. These parameters in *Salix x dasyclados* were not significantly different, but the clones did grow slightly better than other cultivars. Root and shoot ratios are higher for *Salix viminalis* (Table 3) than other clones, and this may confer an advantage following outplanting. Surviving plants will be evaluated and compared with the performance of nonrooted cuttings.

The leaf N, P, and K content varied from 1.12 to 1.92%, 1.04 to 1.84%, and 0.19 to 0.31%, respectively (Table 4). These levels of N, P, and K in the leaves are not likely to be reducing growth rate (Parfitt and Stott 1987; Vihera and Saarsalmi 1994). Furthermore these nutrient levels reflected that the amount of controlled release fertiliser applied has been adequate. The reason for differences in nutrient content of clones was not clear, but it may reflect better growth. This could impact shoot and growth potential in the field soils where nutrient levels are generally low.

Salix hirtei 'Reifenweide' (Table 4) stores more N, P, and K in the leaves than other cultivars, which could indicate better leaf development and shoot growth. Such differences will be evaluated in the field where nutrient levels will be linked to outplanting success and growth rate. To achieve greater predictability in how willow will perform after outplanting, foliar nutrient levels will be an important measure of site suitability.

Field Outplanting

The site selected for willow outplanting is a relatively shallow uniform layer of dry peat, and has already been cultivated. However, the nutrient levels and pH of the soil

Table 4—The amount of nitrogen, phosphorus, and potassium in the leaves after 3 months growing in the greenhouse in the Falkland Islands.

Willow clones	N	K	P
	-----percent-----		
<i>Salix x. calodendron</i>	1.25	1.47	0.29
<i>Salix eriocephala x S. exigua</i> 611	1.37	1.81	.19
<i>Salix viminalis</i>	1.12	1.04	.21
<i>Salix x. hirtel</i> 'Reifenweide'	1.92	1.84	.31
<i>Salix x. dasyclados</i>	1.30	1.56	.21

were considered unsatisfactory for cultivation. Natural shelter was planted on the windward side of the site.

The soil is acid and infertile (Table 5), and could result in poor survival, low growth rate, and difficult establishment of either rooted or nonrooted willow cuttings. The successful establishment of willow for potential different uses will require knowledge of any imbalance and nutritional deficiencies in either plants or soils (Parfitt and Stott 1987), as fast growing willow species have a high nutrient requirement (Vihera and Saarsalmi 1994). Site factors, such as nutrient content, moisture, and pH of the soil, will have a strong influence on the growth and productivity of willows.

On willow sites in the British Isles, the addition of fertiliser in the planting year is not considered necessary. However, considering that rooted and nonrooted willow may not have an adequate reserve to support the first growing season on the Falkland Islands, it is necessary to apply phosphorus fertiliser before and after outplanting (Low and McAdam 1999) and raise the pH towards neutral. Subsequent applications will depend on growth and foliar analysis.

Potential Use for Willows

Since the 1960s, many researchers have become interested in growing varieties of *Salix* spp., as they exhibit a wide range of uses and tolerance of extreme ecological ranges. Willows are utilised in many ways, for example pulp production and woodchips for fuel. These woodchips provide a source of renewable energy that is widely used in Sweden and the UK to reduce air pollution from fossil fuels (Tabbush and Parfitt 1999). In places like the Falkland Islands with environmental limitations, use in shelterbelts would play an important role due to the need to protect livestock and agricultural crops from the strong winds.

The majority of willows provide excellent shelter material, either as quick growing windbreaks behind which other

more permanent species could establish, or windbreak species themselves. Other uses, such as energy (heat production), bioremediation (biofiltration for treating a wide range of waste), browse (fodder), and amenity (gardening) may be included into a practical application programme.

Energy

In the Falkland Islands, willow could be grown to provide a quick shelterbelt around small paddocks. After several harvests, enough material could be accumulated to provide heating using small scale heating systems. It might also be a valuable component of a sustainable organic farming system. It may help in replacing both oil imports and peat consumption from natural reserves. Based on information on farm and housing size and growing conditions from the UK, it is suggested that, to cover individual heating requirements or crop protection in the Falkland Islands, it would be necessary to manage at least 2 ha (5 ac) of willows per house farm.

Bioremediation

The potential use of bioremediation would help the islands to achieve a sustainable economic growth, within the concept of organic status, due to the maintenance of a clean environment. This would improve the fragile rural economic infrastructure of the islands and increase the opportunities for diversification. There are a number of species of willow that produce extensive shallow root systems, providing excellent active phytoremediation systems, removing nutrient elements from wastes. Dawson (1999) suggested 2 major implications for such a system: 1) Animal manure can provide nutrition for the willow crops, while the willow can actively detoxify the waste, removing sensitive elements such as phosphates, nitrates, and some heavy metals. This is particularly relevant on the islands where soils are nutritionally poor. 2) In a climate where rainfall is low, the added water in the waste could prove as valuable as the nutrients in promoting growth of the willow.

Amenity Plantings

Willows are well adapted to human-modified habitats and have been an important part of the human landscape in a wide range of locations. They are commonly included in amenity planting programmes for their attractive foliage, bark, stems, and catkins. It would help to improve Falkland Islands farm settlements where there are no trees and shrubs around houses and gardens. Finally, it is important to mention that there are already willows growing locally that were introduced for shelter and browsing. Willow foliage has been proven elsewhere to be good fodder for sheep, cattle, and horses, as well as for wildlife.

Conclusions

Although the main objective is to introduce willows into the Falkland Islands as a windbreak, it is believed that other uses, such as energy and bioremediation, could be a real

Table 5—Soil analysis of the outplanting site on Fitzroy Farm, East Falklands.

Soil analysis	Level
pH	4.11
Nitrogen (mg/L)	0.5
Potassium (mg/L)	405
Phosphorous (mg/L)	18

alternative, as agriculture has been forced to diversify towards sustainable economic and organic status. Willow already grows widely in a range of situations on the Falkland Islands, clearly demonstrating some evidence for their potential use. Basic production work on willow has been accomplished. However, further information is required on land suitability, performance of other varieties, and nutritional aspects. The containerisation of willow cuttings with better root systems and top growth could considerably help in establishment and quick growth.

In the early stages of this work, where willow was grown under controlled conditions, *Salix viminalis* and *Salix x dasyclados* have performed best. Subsequently, rooted and fully dormant nonrooted willow clones will be outplanted out on a cultivated site at Fitzroy Farm in September 2003 where they could provide an effective shelterbelt and contribute to improving agriculture in a sustainable fashion.

Experience in the UK in development and demonstration of small scale gasification technology to convert wood chips to electricity and heat has shown that, on a reasonable scale, willows could offer the opportunity for use as biomass for energy, bioremediation, and amenity purposes while being used as a shelterbelt.

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