and with the concern for energy supplies we may even find coppiced willows grown for fuel and industrial feed stocks. However, at present the greatest need is for production of specialist nursery material of ornamental willows, willows for reclamation and for windbreaks.

CONCLUSIONS

1) The range of habit, catkins, summer leaf and winter bark exhibited by willows has hardly been exploited for ornamental uses in parks and gardens.

2) There is considerable scope for fast growing cheap, vandal proof bush willows for the rougher type of amenity planting associated with new towns, motorways and other difficult environments where pioneer species are required.

3) Willows are eminently suited for windbreaks required by fruit and vegetable growers.

4) At Long Ashton we have a unique collection of willows which are available in small quantities for trials, for educational purposes and to nurseries who wish to produce new lines in a commercial quantity.

INSTALLING A WARM WATER PROPAGATION FACILITY

DAVID HUTCHINSON[1]

Adas, Hampshire

Objective. To install facilities to propagate 50,000 cuttings with relatively low running cost and moderate capital investment. The system to be on high working efficiency with some flexibility to improve the design if necessary at a later date. Cutting basal temperature required: 70°F.

Design. An oil-fired boiler installation was chosen as the source of heat, as 35 second oil is cheaper than electricity by a factor of 2. A polythene tunnel 100′ × 17′ was already erected on the nursery to a high standard. To accommodate 50,000 cuttings an area of over 1,000 sq. ft. of warmed bed is required. Normally the energy requirement for soil-warmed beds is calculated on the basis of 15 watts of electrical loading per square foot. This is equivalent to 50 BTUs per square foot.

A second-hand 60,000 BTU boiler and a 600-gallon oil tank was purchased cheaply due to the fact that numerous domestic consumers were changing over from oil to natural gas.

Warm water at a temperature of 104°F was fed by a cir-

[1]Horticultural Advisory Officer

culator pump to flow via a header from the boiler to the far end of the bed through 20 half-inch diameter polythene class C BS1972 tube. The warm water was collected by a header and returned to the boiler at a temperature of 95°F by means of a 1½ inch diameter polythene class C BS1972 pipe.

The boiler thermostat was initially set at 105°F; however, when working it was found that the thermostat could be set at 160°F with no problems. Temperature control was by a one probe Nobel controller connected to the circulating pump. The probe was placed at the basal region of the cuttings. A 5-gallon header tank was erected in the ridge of the polythene tunnel. The boiler was lagged with fibre-glass.

Construction. The polythene tunnel was raked level across the width of the tunnel and a 6″ rise was noted from the boiler end to the far end. A sheet of black polythene 500 gauge was laid on the surface of the soil. This was covered by 2″ of sand. A perimeter of two concrete blocks laid on their sides was bedded into the sand to give a height of 8″. The internal measurements were 94′ × 11′.

A header pipe was anchored at each end of the bed. These were made on the nursery and each header pipe had inserted and welded twenty spigots. Each spigot was ½″ in diameter (outside measurement) and 6″ long. The spigots were positioned at 6″ intervals with ¾″ of the spigot protruding inside the 2½″ diameter header pipe. Bleed valves for air release in the system were welded in near the blank ends of the header pipes.

The twenty polythene pipes running down the polythene tunnel were connected to the spigots by heating and expanding the ends of the polythene pipe in boiling water (using a kettle on an extension lead) and securing the pipe in position while still warm with a jubilee clip.

The return pipe of 1½″ diameter class C polythene pipe was installed in the centre of the bed, with two gate valves so that either bed could be switched off from the head source if desired.

A concrete slab (2′ × 1′) access path was laid on top of the sand in the centre of the bed. Four lines of lay flat irrigation tube was laid on the surface of the sand to dampen the sand periodically by means of hand controls.

Installation costs and specification.

Second-hand 60,000 BTU boiler 600 gallon oil tank	£ 80.00
Concrete blocks, 300 @ 18″ × 9″ x 4″	65.00
Sand/grit, 50 cu yd	156.00

Circulating Pump — Grundfoss 2 speed	17.00
Header Pipe 2½″ dia × 26′ @ 22p foot	5.72
Spigots — ⅜″ internal med gal Blue Band	
Steel Tube 40 × 6″	5.00
Polythene Pipe ½″ Class C	
4 coil of 150 m	92.00
Nobel Controller — 1 probe	53.24
Black Polythene 500g	27.70
Path 2′ × 1′ × 2″ slabs	25.71
Chimney — 10′ × 6″ flue Header Tank — 5 gallon Taps — two — 1½″ Return from Pipe 1½″ dia Polythene Class C Welding Rods	98.58
Electrical Work — Installation	7.00
13 amp twin outlet	3.00
Misc Fittings	26.04
Aluminium for Chimney	14.62
Labour — Installation 100 hours	170.00
	£846.61

Additional costs.

Insulation — 48 sheets 1″ Polystyrene 8′ × 4′ sheets		62.40
— Polythene Wrap		50.00
— Labour — 30 hours?		45.00
		£157.40
	Total	£1004.01

Performance. A CO_2 flue gas check was made during the operating period and gave an efficiency factor of 83% combustion. The burner nozzle was rated at just under ½ gallon of 35 second low sulphur oil per hour.

Checks with a 12 probe thermocouple unit showed no temperature difference along the supply header. Across the width of the bed there was a 3°F drop at the sides and a 2°F drop either side of the access path. There was a 5°F temperature gradient down the house from the supply to the return header. The return 1½″ pipe flow dropped 4°F back to the boiler. The Nobel controller was situated near to the return header end of the unit set at a temperature of 65°F at the actual cutting base. (This gave a temperature of 70°F at the top end nearest to the supply header.)

There were 23 nights when the minimum temperature within the polythene tunnel dropped below freezing point. On these occasions the temperature below the polythene film cover over the cuttings dropped to below 50°F and the basal temperature to 60°F recorded at the Nobel probe. During the night with the extreme low temperatures above the polythene film on the cuttings a large amount of condensation occurred and this saturated the cutting and compost in the imperfectly drained trays.

To overcome cutting and compost saturation on days following frosty nights the polythene film cover was removed from the cuttings from 9 am to 4 pm. On sunny days, providing the polythene film cover was replaced around 4 pm, no increase in the amount of heating was required to maintain 70°F at the base of the cuttings.

Fuel consumption.

Table 1. Fuel Consumption — Average Gallons Per Day

	Dec	Jan	Feb	Mar	Apr	May
Gallons per day	6.8	6.8	6.8	4.5	4.0	2.0

Future improvements in design. If installing the system with hindsight, then insulation would be installed during construction in the base and sides as well as lagging the headers. This would improve thermal efficiency by reducing the heat loss on the perimeter of the bed and adjacent to the path.

To improve the temperature gradient down the tunnel a flow and return system installed side by side would be contemplated. This would call for an additional return header which would be installed alongside the flow at the boiler end. This would mean we could dispense with the 1½" diameter return under the path.

Cutting trays should be deep with numerous drainage holes. The more plentiful the better providing the compost does not fall through.

The polythene cover over the cuttings could be supported on the hoops or steel or polythene tube so that excess condensation can be returned to the sand base via the edges of the bed and not through the cutting tray.

Conclusion. That a circulated warm water system can be efficient and economical, for soil warming with a high degree of accuracy.

Two questions arise: 1) What are the basal temperature requirements? and 2) Do we need constant heat or can intermittent heat be used successfully to reduce heat inputs?

Acknowledgments. I wish to thank Mr. R. F. Mann, Mr. M. J. Mundy ADAS Mechanisation Advisers, and Mr. M. S. Blunn for their help in designing and accomplishing this work.