The Adventitious Rooting of Vegetative Cuttings Using Hydropropagation

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INTRODUCTION

Cuttings need external conditions that will minimise stress, if they are to survive and form roots (Elliot and Jones, 1980). These conditions involve water, temperature, light and oxygen. Protecting the cutting from water stress is usually achieved by misting or fogging. Temperature is often regulated so that the rooting medium is 5 to 10C warmer than the aerial temperature. High light intensity can result in overheating of the cutting and consequently shading is preferable, particularly under glass. Oxygen is essential for root formation (Zimmerman, 1930) and poor aeration conditions due to waterlogging will lead to death of cuttings. Factors such as the use of rooting hormones (auxins) (Thomas, 1982) and slow-release fertiliser in the rooting medium (Carter, 1985) can promote quicker rooting of cuttings.

Boland and Hanger first described the concept of hydroponic propagation (Boland and Hanger, 1991). The system potentially overcame water stress by standing the cuttings in aerated recycling water. The solution could be heated to create a warm rooting zone and the inclusion of a low concentration of IBA in the water for an optimal period accelerated early root development.

This paper describes a series of studies using the hydropropagation methods. The aims were to study a range of test plants:

1) Determine the effects of auxin type, concentration, and exposure time.

2) Determine any benefit of low concentration nutrients being added to the recycling water.

3) Show that hydropropagated cuttings established well in standard potting mix.

4) Determine whether fogging could improve rooting.

MATERIALS AND METHODS

The hydropropagation modules consisted of galvanised powder-coated channels 2.3 m long, 100 mm wide, and 40 mm deep, filled with black polypropylene beads, approximately 4 mm by 3 mm in size. Channels were supported on galvanised iron benches that had a slope of 1 : 11. At the lower end the beads were retained by a wad of foam that allowed water to drain back to the reservoir.

Submersible pumps were used to pump the solutions from 42-litre plastic drums through 13-mm tubes to the upper ends of the channels where plastic jets delivered the solution at approximately 500 ml/min. Solution depth depends on the degree of incline and flow rate but was generally approximately 15 mm. The system was located in a heated glasshouse (minimum air temperature 16 to 18C) that was covered with 60% shade cloth and contained a fogging system that on occasion was used to maintain relative humidity at a minimum of 75%.

When required, solution temperature was raised by heat exchange from coiled 15-mm black irrigation tubing in each reservoir. Water heated to 35C was circulated through the tubing and the flow was controlled by solenoid valves linked to Datataker® and Iopack® control units. Details of the combination of treatments for each species are shown in Table 1.

With some species a second batch of cuttings was propagated in a heated mist bed with bottom heat set at 21C and 8 sec misting at 8 to 10 min intervals. The medium used was 1 sterilized washed sand : 1 perlite : 1 sieved peat moss (by volume). Results obtained in the mist bed could not be compared statistically with hydropropagation but did indicate differences or similarities between the two systems.

Table 1. Summary of hydropropagation treatments, environment, and test plants.

Plant	*Swainsona formosus*	*Daphne odora*	*Rosa banksiae* var. *banksiae*	*Eucalyptus ficifolia*	*Banksia ericifolia*	*Melaleuca gibbosa*
Commenced	13 Jan	31 Jan	13 Mar	6 July	17 Dec	21 Dec
Duration (weeks)	4	4	6	8	6	4
Hormone:						
Auxin (potassium salts)	IBA or NAA	IBA	IBA	IBA	Nil	IBA
Concentration (ppm)	10	10	5	0.2 or 5	"	2 or 10
Exposure time (days)	14	14	12	7 or cont.	"	7
Nutrient:						
Strength [1]	Nil	0.5	0.25	Nil	Nil	Nil
Start @ day	"	16	5 or 10	"	"	"
Renewal (days)	"	14	14	"	"	"
Recycling solution:						
Continuous flow	✓	✓	✓	✓	-	✓
Pulsed flow	-	-	-	-	✓	-
Temperature °C:						
Setpoint	21	-	-	22	23	-
Ambient	-	✓	✓	-	-	✓
Medium:						
Beads (only)	✓	✓	✓	✓	✓	✓
Beads:peat	-	-	-	-	✓	-
Light (µEm-2 s-1 PAR)	390	390	390	860	960	960
Fog (75% RH)	-	-	-	-	✓	✓/-
Cutting:						
Length (cm)	8-14	10-12	6	15	8	7
Node number	2-3	2-3	2-3	2 or 4	50	75
Number (per treatment)	46	45	39	24	45	51

[1] Full strength 2 ds/m; composition after Cooper (1979).

RESULTS

Sturt's Desert Pea (*Swainsona formosus*). Sturt's desert pea terminal cuttings were easy to root using the hydropropagation technique (Table 2a). NAA was toxic when applied at a rate of 10 mg/litre for 14 days. IBA did not increase percentage strike but did promote a larger root mass than cuttings which received no auxin. NAA and IBA used as quick dips (2500 mg/litre for 5 sec) were both beneficial to rooting in the mist bed (Table 2b).

Table 2a. Effect of auxin type on rooting of Sturt's desert pea and the presence of *Botrytis* sp. after 4 weeks hydropropagation.

Hormone	Rating (%)	Botrytis (%)	Strike (%)
Control (zero hormone)	3.08	0	92.9
IBA	3.48	0	98.9
NAA	1.44	0	36
LSD 0.05	0.37	ns	17.9
LSD 0.01	0.49	ns	23.5

Table 2b. Effect of auxin type on the rooting of Sturt's desert pea and on the incidence of *Botrytis* sp. after 4 weeks mist bed propagation.

Hormone	Rating (%)	Botrytis (%)	Strike (%)
Control (zero hormone)	2.52	85.3	77.7
IBA	2.90	59.8	88.8
NAA	3.19	66.3	93.2
LSD 0.05	0.28	20.9	7.8
LSD 0.01	0.37	29.3	11.0

In the hydropropagation system no*Botrytis* was present whereas a high incidence of*Botrytis* was present on cuttings propagated in the mist bed.*Fusarium oxysporum* was isolated from the roots, symptoms being root rot (browning) and wilting of the cutting.

Melaleuca gibbosa. Results in Table 3 show that either 2 ppm or 10 ppm IBA stimulated rooting. However the lower IBA concentration appeared to be the better treatment under nil-fog conditions. The number of roots produced was also greater in the absence of fog.

***Rosa banksiae* var. *banksiae*.** Incorporating IBA into the recycling solution was toxic to*Rosa banksiae* var. *banksiae* [syn.*R. banksiae* 'Alba'] and all cuttings died when IBA was present at a concentration of 5 ppm. Cuttings that were not treated with IBA rooted successfully and the early introduction of quarter-strength nutrient at day 5 to the hydropropagation recycling solution was beneficial to early root development. Cuttings receiving nutrients had increased root number and length compared to nil nutrients after 3 weeks and this was later reflected at week 6, with improved early shoot development (Table 4).

Table 3. Effect of auxin concentration on the rooting of *Melaleuca gibbosa* after 4 weeks hydropropagation in a fogged or nil-fogged environment.

Environment	Hormone (per liter)	Strike (%)	Root length maximum cm.	Total root number
Nil-fog	Control(zero IBA)	28	0.4	6.3
	IBA 2 mg	87	4.4	41.6
	IBA 10 mg	61	4.0	20.0
	LSD 0.05	-	1.4	9.4
	LSD 0.01	-	3.3	12.4
Fog	Control (zero IBA)	4	0.1	0.2
	IBA 2 mg	65	2.2	6.7
	IBA 10 mg	67	4.1	8.4
	LSD 0.05	-	1.2	3.9
	LSD 0.01	-	1.6	5.1

Table 4. Effect of nutrient timing during propagation on root and shoot developement of *Rosa banksiae* var. *banksiae*.

Nutrients started	Root		Shoot	
	number	length maximum (cm)	number	length total (cm)
	3 weeks		6 weeks	
None	0.2	3.9	0.9	2
Day 5	1.8	21.4	1.3	7
Day 10	1.1	9.8	1.7	3
LSD 0.05	0.8	10.1	0.5	2

Cuttings from each treatment were grown on in a standard pine-bark-based potting media and were assessed after 5 and 15 weeks. There was no significant carryover effect of the early nutrient introduction during propagation but hydropropagated cuttings did grow faster than mist-bed propagated cuttings.

Banksia ericifolia. Cuttings of this species swelled at the base, but did not root, when they were placed in plastic beads with continuously recycling water. Intermittent recycling (15 min on/15 min off) did not improve the result. When cuttings were placed in a medium consisting of 5 plastic beads : 1 peat moss (approximately v/v) 62% rooting was achieved in 6 weeks without recycling water. The rooting increased to 82% when intermittent recycling was used in combination with the beads/peat medium (Table 5).

Table 5. Effect of support medium and solution pulsing on the rooting of *Banksia ericifolia* using hydropropagation grown in a fogged environment.

Medium	Flow	Strike (%)		Callused or swelling (%)		Dead (%)	
		4 weeks	6 weeks	4 weeks	6 weeks	4 weeks	6 weeks
Beads	Pulsed	0	0	6	84	0	8
Beads	Continuous	0	0	19	90	0	10
Beads & Peat	Pulsed	60	82	0	15	0	4

Daphne odora. *Daphne odora* is considered to be of moderate difficulty to strike by conventional propagation. Incorporating IBA into the recycling solution at a concentration 10 mg/litre for a period of 14 days significantly advanced root development (Table 6a); 98% of cuttings were struck in 4 weeks compared to 71% for cuttings which received no auxin. Root number, maximum length, and root dry weight were all significantly increased. Incorporating nutrients into the solution at day 16 did not significantly increase root or shoot growth over the next 12 days.

By comparison, cuttings propagated in the mist bed were inferior in development after 4 weeks with only 37% of cuttings struck, fewer roots, and less growth (Table 6b). IBA (2,500 mg/litre for 5 sec) did not significantly improve rooting under mist-bed conditions.

Table 6a. Effect of hydropropagation on root development of *Daphne odora* after 4 weeks.

Treatment	Strike (%)		Root		Dry weight (g)	
			Number	Length (max.) (cm)	Shoot	Root
Control (zero IBA)	70.5	(50.5)	17.8	17.5	16.0	1.3
IBA	98.7	(88.3)	51.7	39.3	14.6	8.5
IBA + Nutrients	97.3	(80.7)	53.3	38.1	15.9	11.3
LSD 0.01	7.9	(15.4)	13.8	7.7	NS	5.1

Table 6b. Effect of mist bed propagation on root development of *Daphne odora* after 4 weeks.

Hormone	Strike (%)		Root	
			Number	Length (max.)(cm)
Control (zero IBA)	37	(16)	5.3	1.0
IBA	35	(16)	6.0	0.9
LSD 0.05	ns	ns	ns	ns

Note: ( ) Percentage of quality cuttings having >10 roots and the shortest root was >1.5 cm.

***Grevillea* Species and Hybrids**. Only limited success was achieved with Grevilleas. Cuttings of 'Poorinda Peter' developed basal callus but had not formed roots within 6 weeks. Nine per cent of Ivanhoe cuttings rooted after treatment with 2 ppm IBA for 7 days. However, if concentration of IBA was increased to 10 ppm, 84% of cuttings died within 6 weeks.

Under fog conditions 23% of *G. rosmarinifolia* cuttings rooted within 6 weeks and this increased to 63% if cuttings were exposed to 2 ppm IBA for 7 days. However, if cuttings were not maintained under fog conditions the IBA was toxic even at the low concentration of 2 ppm.

Eucalyptus ficifolia. The hydropropagation technique did not promote roots on cuttings of adult *Eucalyptus ficifolia*.

Hydropropagation did however stimulate the production of callus which had root-like appearance but lacked organised meristems. This callus developed on approximately 50% of two-leaf cuttings, and cuttings potted into a pine-bark media and held in a fogged environment have remained alive for approximately 11 months and developed new shoot growth up to 4 cm long.

CONCLUSION

For some plants e.g., *D. odora*, incorporating auxin at low concentration for short exposure time (2 to 14 days) can advance root initiation at optimal concentration and promote a high quality root development. However, auxin is not always necessary, and in some cases (e.g. *G. rosmarinifolia*) can be toxic even at low concentrations (2 ppm). The importance of hormone type and toxicity was highlighted by *S. formosus*.

The early addition of low-strength nutrients can be beneficial to advance early root and shoot development. Hydropropagated cuttings (e.g., *R. banksiae* var. *banksiae*) can be successfully grown on using standard pine-based potting media.

The failure of cuttings to root using hydropropagation may, in some instances, be due to inadequate aeration of the recycling solution. The use of aeration stones or intermittent recycling on a short time interval may be beneficial.

Using peat in the recycling solution was beneficial in promoting rooting as shown with *B. ericifolia*. Therefore, investigation of whether this was a pH effect or caused by other factors may prove useful.

Fogging in combination with hydropropagation can be mutually root enhancing for some plants, e.g., *G. rosmarinifolia* but may not be always necessary if the house relative humidity is maintained at a high level. However, fogging delays or reduces the risk of hormone toxicity.

Hydropropagation has potential but requires further experimentation before it could be commercially viable.

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