pies becomes more expensive the grower will go to many means to reduce the time the plant occupies that space. This gets back to the breeder because if the new plant does not give the grower the proper return for a given "space-time slot" then he will grow something that will. The grower will be looking at a world market and will become very flexible in his ability to shift from growing one crop to another to maximise his return on investment. Flexibility will spell profits and inflexibility will mean disaster in the times ahead in North America.

A MEASURE OF THE CONSISTENCY OF THE RESPONSE OF CUTTINGS TO PROPAGATION TREATMENTS AS A GUIDE TO THE VALUE OF EXPERIMENTS ON NURSERIES [1]

B. H. HOWARD

East Malling Research Station
Maidstone, Kent

Abstract. Twenty-three experiments on the propagation of conifers and other woody plants by stem cuttings were done on nurseries by members of the Society The experiments fell into three groups and within each group the same member repeated the experiment in a second year under the same conditions as on the first occasion Treatments investigated the effects of basal wounding in association with other factors which could influence the wounding response Group 1 experiments examined the effect of wounding and the influence of an incision or slice wound on rooting In Group 2 the effect of auxin applied before or after making the wound was investigated. In Group 3 wounding was examined in association with the use of a liquid or powder formulation of root-promoting auxin, with subsequent rooting in a 'wet' or 'dry' regime

Within each group, wounding consistently improved rooting but the response to all other factors was variable and inconsistent Significant interactions of wounding and other treatments with nurseries and with years revealed unidentified factors which influenced the rooting response of cuttings to these treatments

INTRODUCTION

Between 1970 and 1973 three groups of experiments co-ordinated from East Malling Research Station were undertaken by members of the G B. & I. Region, with the object of determining the general value of wounding stem cuttings and of understanding

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[1] Thanks are due to Miss C Jackson of East Malling Research Station for handling the statistical aspects of these trials, and to D N Whalley for arranging distribution of cutting material from the Glasshouse Crops Research Institute

the mechanism behind the wounding process in terms of uptake of auxin and water.

Each group of experiments involved different treatment combinations which also differed in their complexity. The first year's results showed that great variability between nurseries occurred in the response to anything other than the main effect of wounding, even when in Group 3 the species, clone and origin of the cutting material was largely standardised. It therefore became necessary to assess the type of information these experiments could provide. Each experiment was repeated to obtain further information on the consistency of response between nurseries and on the consistency within nurseries in different years at the varying levels of treatment complexity. Only data from members contributing results in both years are discussed.

MATERIALS AND METHODS

Group 1. In 1972 six experiments were undertaken to compare unwounded cuttings with those wounded by the removal of a slice of tissue penetrating the wood at the base of the stem, and with those wounded by two incisions made with the point of a knife on opposite sides of the stem base. All wounds were up to 1 in. in length, differing in size between nurseries but being similar in size in different years on any one nursery After wounding, cuttings were treated with auxin to the depth of the wound, or its equivalent, and placed under intermittent mist in a randomised layout with each treatment represented by five replicates with 20 cuttings per plot Four of the six experiments were done using X *Cupressocyparis leylandii* and all were repeated in 1973 Full details are given in the appendix

Group 2. In 1970 six experiments were undertaken to compare unwounded cuttings with those wounded by a single basal slice, either preceded or followed by application of auxin to the depth of the wound or its equivalent. Replication and plot size were the same as for Group 1 experiments. Six different species were used and propagation conditions varied accordingly. These experiments were repeated in 1973 and full details are given in the appendix.

Group 3. In 1970 eleven experiments were undertaken to compare factorially the effect of wounding by removal of a single slice of tissue with unwounded cuttings, followed by application of 4,000 ppm indolyl butyric acid (IBA) as a proprietary powder formulation (Seradix 2) or dissolved in 50% ethanol and used as a 5 second 'quick dip'. Cuttings were then placed under intermittent mist in a 'dry' regime with relatively infrequent misting or

were placed in a 'wet' regime where supplementary water was given, usually with a fine-rose watering can. Three replicates with 15 cutting plots were used and the experiment was repeated in 1973. X *Cupressocyparis leylandii* clone 2 was used throughout, supplied to those members not having a local source by distributing branches from trees growing at the Glasshouse Crops Research Institute (G C.R.I.). Full details are given in the appendix.

Participants recorded the cuttings by placing them in five categories ranging from 'dead' to 'excellently rooted' and the data was sent to East Malling to be treated in two ways. Analysis was carried out on the percentage of rooted cuttings irrespective of grading, and also on weighted values obtained by multiplying the totals of the best rooted cuttings by a factor of 4 and the totals of progressively poorer grades by x3 or x2. Callused cuttings received a 'weighting' of x1 and dead cuttings were ignored. The weighting method gave emphasis to the production of the heavily-rooted cuttings preferred by nurserymen and the data presented in the tables were obtained in this way. Results were generally similar from both methods but attention is drawn to some differences.

Table 1. Weighted score for rooting per cutting related to the presence and type of wound (maximum potential = 4)

Group 1 Nurseries	Year	Slice wound	Incision wound	Control No-wound	Horizontal means	
1	1972	3 06	2 97	2 66	2 90)	2 34
	1973	1 59	2 06	1 67	1 77)	
2	1972	2 63	2 51	2.44	2 53)	1 99
	1973	1 54	1 53	1 28	1.45)	
3	1972	2 87	2 91	3.17	2 98)	2 92
	1973	2 82	2 90	2.84	2 85)	
4	1972	2 16	2.04	1 87	2 02)	1 39
	1973	0 79	0.83	0 63	0 75)	
5	1972	3 53	3 42	3 30	3 42)	2 77
	1973	2 43	2 27	1 66	2.12)	
6	1972	2 93	2 70	2 32	2 65)	2 65
	1973	2 84	2 85	2 26	2 65)	
Vertical means		2 43	2 42	2 18		

SE of vertical means $\pm$ 0 052 with 96 df
Significance levels
Slice and incision wounds v control P<0 001
Slice v incision wound N/S

RESULTS

Group 1. In eleven out of the twelve possible comparisons one or other of the wounding treatments was superior to the unwounded control (Table 1) and the general benefit of wounding (slice and incision) was significant (P-0.001). There was no overall difference due to the type of wound employed. In 1972 the slice wound gave slightly better results than the incision method, while the reverse trend occurred in 1973 and only in two cases was the treatment order of effectiveness similar in both years.

The relative improvement due to the overall wounding effect (both methods v control) was greater in 1973 than in 1972, the interaction being significant (P-0.01) in terms of percentage rooting but not on the basis of weighted data. The overall rooting level was also much poorer in 1973 than in 1972. The value of wounding (both methods vs control) differed on different nurseries, the interaction reaching a significance level of P-0.1.

Group 2. In eleven out of the twelve possible comparisons one or other of the treatments which included wounding was superior to the unwounded controls (Table 2) and the general benefit of wounding (with auxin application before and afterwards)

Table 2 Weighted score for rooting per cutting related to the application of auxin before or after wounding (maximum potential = 4)

Group 2 Nurseries	Year	Auxin before wounding	Auxin after wounding	Control, auxin but no-wound	Horizontal means	
7	1970	3 60	2 05	3 35	3 00)	2 22
	1973	1.93	1 35	1 04	1 44)	
8	1970	1 61	1 49	1.00	1 37)	1 33
	1973	1 22	1 59	1 05	1 29)	
9	1970	2 49	2 03	2 48	2 33)	2 05
	1973	1 76	1 74	1 80	1 77)	
10	1970	1 23	2 34	1 16	1 58)	2 01
	1973	2 41	2 83	2 12	2 45)	
11	1970	2 14	2 07	1 38	1 86)	2 11
	1973	1.96	2 86	2 26	2 36)	
12	1970	2 98	2 94	2 08	2 67)	2 63
	1973	2 95	2 78	2 06	2 60)	
Vertical means		2 19	2 17	1 81		

SE of vertical means $\pm$ 0 054 with 96 df
Significance levels
Wounding (auxin before and after) v control $P < 0\ 001$
Auxin application before wounding v afterwards N/S

was significant (P-0.001). There was only a small and non-significant effect due to the timing of the auxin application, but there was a signifficant interaction with years (P-0.05) and only in two cases was a similar order of treatment success observed in both years. Overall, results for 1970 were better than for 1973 but nurseries differed greatly possibly because they used different species. Accordingly, the interactions between nurseries and overall wounding (at both times of auxin application) and between nurseries and the time of auxin application were significant (P-0.001)

All higher order interactions of overall wounding, or time of auxin application with years and nurseries were also significant (P-0.05). Percentage rooting showed identical trends throughout.

Table 3. Weighted score for rooting per cutting related to wounding and the formulation of IBA (means of 'dry' and 'wet' regimes, maximum potential = 4)

Group 3 Nurseries	Year	Wounds		No wounds		Horizontal means	
		Powder IBA	Liquid IBA	Powder	Liquid		
13	1972	2 17	1 69	2 04	1 50	1.85)	1 91
	1973	1 97	2.52	1 77	1 64	1 97)	
14	1972	2 08	0 90	0 50	0 20	0 92)	1 56
	1973	2 58	2 19	1 86	2 16	2 19)	
15	1972	2 49	2 87	0 96	1 42	1 93)	1 78
	1973	2 30	2 21	1 02	0 97	1 63)	
16	1972	2 83	3 50	2 17	2 58	2 77)	2 34
	1973	2 29	1 54	2 31	1 53	1 92)	
17	1972	2.82	2.23	2 56	2 55	2.54)	2 12
	1973	1 74	1 76	1 59	1 69	1 69)	
18	1972	2 04	2 14	1 97	2 29	2 11)	2 13
	1973	2 30	2 20	1 99	2 11	2 15)	
19	1972	2 38	2 62	1 67	2 43	.2 27)	2 42
	1973	2 12	3 07	2 03	3 02	2 56)	
20	1972	1 84	1 88	1 86	1 21	1 70)	1 12
	1973	0 58	0 58	0 64	0 38	0 54)	
21	1972	2 19	2 07	1 72	1 71	1.92)	2 02
	1973	2 23	1 53	2 57	2 14	2 12)	
22	1972	2 66	2 69	1 72	2 11	2 29)	2 56
	1973	2 94	2 78	2 77	2.81	2 82)	
23	1972	2 68	2 76	2 52	2 39	2 59)	2 52
	1973	2 17	2 69	2 34	2 66	2 46)	
Vertical means		Wound = 2 23			No wound = 1 87		
		Powder 2 05			Liquid 2 05		

SE of vertical means ± 0 031 with 264 df
Significance levels
Wounding v controls P<0 001
Powder v liquid formulation N/S

Group 3. Results for wounding and IBA application are given as overall means of the 'wet' and 'dry' conditions, and the latter are considered separately because these treatments, which were represented only once on each nursery with no opportunity of separate statistical analysis, interacted least with other factors.

Seventeen out of the twenty-two possible comparisons showed an overall improvement from wounding (Table 3) and this effect taken over all nurseries was significant (P-0.001). On the other hand, the use of powder or liquid formulations of IBA gave identical results overall (Table 3), with 12 comparisons in favour of the powder and 10 in favour of the liquid formulation. The response to wounding differed with years, being relatively more beneficial in 1972 than 1973 (P-0.001). In terms of rooting percentage the significance level of this interaction was P-0.05. The response to both wounding and IBA formulation differed between nurseries even though in these experiments the same cultivar was used throughout (P-0.001). Higher order interactions also existed. Out of eleven nurseries, six were consistent and five inconsistent and six not in the response to IBA formulation.

The effect of 'wet' or 'dry' propagating regimes was negligible, the overall mean rooting score being 2.05 and 2.04 respectively. Eleven of the twenty-two comparisons were in favour of the 'wet' regime and eleven not. Only four nurseries obtained consistent results in favour of one or the other regime in both years. Interactions with other treatments were least for the moisture factor, reaching a probability of -0.05 only in association with the formulation of IBA used. (P-0.01 in terms of percentage rooting)

DISCUSSION

These results clearly show that although the relative value of wounding differed in different years it was generally beneficial. The effects of type of wound, time of auxin application, or type of IBA formulation varied between experiments, such factors apparently being of secondary importance relative to the presence of the wound and use of auxin in some or other form.

The significant interactions of both wounding and auzin treatments with nurseries clearly shows that local conditions exert a strong influence on the rooting process, especially in Group 3 experiments where the same cultivar was used throughout Such factors are likely to include the condition of the cutting material and the detailed way in which it is handled by staff who changed from year-to-year in some of these experiments. Observation of propagation procedures and conditions on nurseries with reasonable yearly consistency, but which differed with respect to treatment responses, such as Nos. 14 and 19 in Group

3, could provide a clue as to the nature of these unidentified factors. However, it is unlikely that their detailed investigation in search of propagation mechanisms could be undertaken elsewhere than at a Research Station where close and continuous observation is possible. The main function of the Society's experimental programme involving commercial nurserymen should be aid in the development of new research techniques by testing their general application over a wide range of conditions and subjects

APPENDIX

Group 1.

1) A B MacDonald, Hadlow College of Horticulture, Kent X *Cupressocyparis leylandii*
   a) 4-2-72 to 19-5-72 Cuttings treated with Seradix No 2 and placed under mist with 21°C basal temperature
   b) 7-2-73 to 26-4-73. 'Conditions as for previous year'
2) P D A McMillan-Browse, Brooksby Agricultural College, Leicestershire X *Cupressocyparis leylandii* (clone 2)
   a) 12-1-72 to 10-5-72 Sub-terminal cuttings treated with Seradix No 2 and placed under mist with 21°C basal temperature
   b) 9-1-73 to 15-5-73 'Conditions as for previous year, but cutting material of poorer quality'
3) D G Pope, St Bridget Nurseries, Exeter, Devon *Elaeagnus pungens* 'Maculata' ('Aurea Variegata')
   a) 8-2-72 to 26-5-72 Tip cuttings treated with 4,000 ppm IBA alcoholic solution and placed under mist with 17°C basal temperature
   b) 10-1-73 (weaned from end of May) to 23-8-73 'Conditions as for previous year except for 21°C basal temperature
4) C G Thomas, Long Ashton Research Station, Bristol X *Cupressocyparis leylandii*
   a) 25-1-72 to 2-5-72 Cuttings treated with Seradix No 2 and placed under mist at 21°C basal temperature
   b) 25-1-73 to 4-5-73 'Conditions as for previous year'
5) D N Whalley, Glasshouse Crops Research Institute, Littlehampton, Sussex *Viburnum* x *bodantense*
   a) 16-5-72 to 6-6-72 Tip cuttings treated with Seradix No 2 and placed under mist at 18°C basal temperature
   b) 22-5-73 to 14-6-73 'Conditions as for previous year'
6) F Willard, A Goatcher and Son, the Nurseries, Washington, Sussex. X *Cupressocyparis leylandii* (clone 2)
   a) 2-2-72 to 24-5-72 Tip cuttings treated with Seradix No 2 and placed under mist at 16°C basal temperature
   b) 2-2-73 to 23-5-73 'Conditions as for previous year'

Group 2

7) M G Adcock, Hillier and Sons, Winchester, Hants *Rhododendron* 'Lady Clementine Mitford'
   a) 21-9-70 to 10-6-71 3 0 in cuttings with 1 0 in slice wound and treated with 5,000 ppm IBA in alcoholic solution, placed under mist with 20°C basal temperature

b) 9-1-73 to 12-7-73 'Conditions as for previous year except for a higher sand content in rooting medium'

8) D M Donovan, F Toynbee Limited, Bognor Regis, Sussex *Polygonum baldschuanicum*

a) 11-1-70 to 5-4-70 3 0 to 4 7 in nodal hardwood cuttings with 0 6 in slice wounds and treated with Boots Hormone Rooting Powder, placed under mist with 24°C basal temperature

b) 14-1-73 to 15-4-73. 'Conditions as for previous year'

9) J I Hulme, University of Liverpool, Botanic Garden, Ness, Cheshire *Juniperus sabina* 'Tamariscifolia'

a) 12-2-70 to 7-7-70 3 0 in lateral cuttings with trimmed heel with 0 5 in slice wounds and treated with 1,000 ppm IBA in alcoholic solution, placed under mist with 21°C basal temperature

b) 5-2-73 to 23-5-73 'Conditions as for previous year'.

10) J G D Lamb and J C. Kelly, The Agricultural Institute, Kinsealy, Dublin, Eire *Prunus laurocerasus* 'Otto Luyken'

a) 16-1-70 to 10-2-70 2 0 to 2 8 in nodal cuttings with 0 8 in slice wounds and treated with Seradix No 2, placed under mist with 21°C to 24°C basal temperature

b) 7-2-73 to 12-3-73 Slightly longer cuttings but otherwise 'conditions similar to the previous year'

11) C H R Madge, East Malling Research Station, Kent Apple rootstock, 'M 26'

a) 19-3-70 to 16-4-70 24 0 in basal hardwood cuttings propagated without mist, 0 7 in slice wound and treated with 2,500 IBA in alcoholic solution at 21°C basal temperature

b) 14-3-70 to 12-4-70 'Conditions as for previous year'

12) F Willard, A Goatcher and Son, Washington, Sussex X *Cupressocyparis leylandii*

a) 27-1-70 to 14-9-70 4 0 to 6 0 in nodal tip cuttings with 0 6 in slice wounds and treated with Seradix No 3 Placed under mist with 16°C basal temperature

b) 5-2-73 to 23-5-73 'Conditions as for previous year'

Group 3 — All X *Cupressocyparis leylandii* (clone 2)

13) M G Adcock, Hillier and Sons, Winchester, Hants

a) 21-1-72 to 14-7-72 3 0 to 6 0 long cuttings with heel. Basal temperature 19°C in a medium of 1 peat 3 sand + Supplementary water given at 3 to 4 day intervals

b) 21-1-73 to 21-5-73 'Conditions as for the previous year'

14)*D N Clark, Notcutts Nurseries Limited, Woodbridge, Suffolk

a) 18-1-72 to 16-5-72 Lateral cuttings with brown base Basal temperature 21°C in a medium of equal parts peat and grit. Supplementary water given at unspecified frequency, no mist during dull weather

b) 16-1-73 to 15-5-73 'Generally wetter conditions than in previous year'

15) Miss L W Dick, West of Scotland Agricultural College, Ayr

a) 2-2-72 to 23-5-72 6 0 to 8 0 long cuttings Basal temperature 24°C to 27°C in a medium of 3 peat 1 sand Supplementary water given daily

b) 2-2-73 to 22-5-73 'Conditions as for the previous year'

16) A B MacDonald, Hadlow College of Horticulture, Kent

a) Early February to 12-6-72 Basal temperature 21°C in a 2 peat, 1 grit, 1 sand, medium

b) 2-5-73 to 4-7-73 No conditions specified

17) P D A McMillan-Browse, Brooksby Agricultural College, Leicestershire
   a) 12-1-72 to 10-5-72 4 0 to 5 0 long three dimensional subterminal cuttings with brown bases Basal temperature 21°C in a medium of 1 peat 1 grit Heavy supplementary watering each morning
   b) No conditions specified, but experiments repeated in other groups conformed between years

18)*J M Richardson, E R Johnson (Nurseries) Limited, York
   a) 19-1-72 to late May. Medium of 4 peat 1 lime-free sand. 'Dry' area watered infrequently by can, 'Wet' area received intermittent misting.
   b) 9-1-73 to 31-5-73 4 0 to 6 0 in trimmed cuttings Medium as in previous year with basal temperature of 21°C 'Dry' area received intermittent mist Wet area was misted and received supplementary water. Rain water was used throughout.

19) J P Sutherland, North of Scotland College of Agriculture, Inverness
   a) 2-2-72 to 25-5-73 Apical three dimensional cuttings with brown bases Basal temperature of 21° to 24°C in a medium of 1 peat 1 sand.
   b) 5-2-73 to 8-6-73 'Conditions as for previous year with cuttings in the 'dry' regime covered at night with polythene and those in the 'wet' regime given a light supplementary spray each morning

20)*C G Thomas, Long Ashton Research Station, Bristol
   a) 25-1-72 to 2-5-72 3 0 in long cuttings. Basal temperature 21°C in a medium of equal parts peat and sand Supplementary water given each morning Benomyl applied against botrytis infection after 8 days.
   b) 25-1-73 to 4-5-73 'Conditions as for the previous year'

21)*A Turner, Royal Horticultural Society Gardens, Wisley, Surrey
   a) 20-1-72 to 23-5-72 10 0 in cutting Medium of equal parts sphagnum moss peat and Thames River grit.
   b) 9-1-73 to 2-7-73 6 0 in cuttings with a heel, with bottom heat of 21°C in the medium

22)*D N Whalley, Glasshouse Crops Research Institute, Littlehampton, Sussex
   a) 9-2-72 to 9-5-72 6 0 in long lateral cuttings with brown bases Basal temperature of 21°C in a medium of equal parts peat and grit Supplementary water given at 2 day intervals.
   b) 16-1-73 to 17-4-73 'Conditions as for the previous year'

23) F Willard, A Goatcher and Son, Washington, Sussex
   a) 1-2-72 to 25-5-72 4 0 to 6 0 in tip cuttings Basal temperature of 16°C in a medium of equal parts moss peat and grit Mist applied during the day only, with supplementary water applied at unspecified intervals as required by weather conditions
   b) 2-2-73 to 24-5-73 'Conditions as for the previous year'

Glasshouse Crops Research Institute cutting source
+It is assumed that ratios are by volume throughout