ROOTING INVESTIGATIONS OF POINSETTIA STEM CUTTINGS

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ABSTRACT

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STEM CUTTINGS

By

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A study was made to determine the rooting response of poinsettia terminal stem cuttings to auxins, growth regulators, and experimental chemicals. Experiments were designed to evaluate these compounds for root promotion, explore the response of several poinsettia cultivars, study the effect of root-promoters during the time cuttings are in the propagation bench, and assess the subsequent growth and flowering of auxin-treated cuttings.

Of the 25 chemicals evaluated, the auxin-containing substances promoted rooting the greatest. Jiffy Grow (IBA and NAA) at 1000 ppm and Hormodin No. 2 (0.3% IBA) applied separately and in combination produced the greatest root number and root fresh and dry weights of all chemicals tested. Chloromone, which contains an auxin-like compound, at 750 ppm also enhanced rooting. With these chemicals, an increase in root fresh weight accompanied the increases in root number, thus resulting in a higher quality rooted cutting.

The nine poinsettia cultivars responded similarly to the auxin-containing chemicals. The dual treatment of a liquid dip into either Jiffy Grow at 1000 ppm or Chloromone at 750 ppm followed by a powder dip into Hormodin No. 2 stimulated rooting the greatest in all cultivars studied except Marble Hegg. In the winter, the combination treatment of Jiffy Grow and Hormodin significantly increased rooting over the separate application of these chemicals, while in the summer there was increased benefit with use of the dual treatments with only cultivars C-1 Red and Annette Hegg Supreme. Those cultivars, as C-1 Red and Ecke White, which produce low root number and fresh root weight without root-promoters, responded the greatest to the auxins.

In both the summer and winter, auxins produced cuttings which rooted as well or better at 20 days after sticking than untreated cuttings at 14 days. The combination treatments of Jiffy Grow plus Hormodin and Chloromone plus Hormodin promoted rooting the greatest at all four sampling dates. Separate applications of these chemicals stimulated rooting as well as the dual treatments in the summer, but not in the winter.

Plant height at flowering was increased over control plants by use of these auxin-containing substances during propagation. Increases in bract diameter were nonsignificant. The time to flower was reduced by 5 to 9 days.

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AN EVALUATION OF GROWTH REGULATORS AND AUXINS FOR ROOT PROMOTION OF POINSETTIA CUTTINGS

Introduction

The use of root-inducing substances in the propagation of vegetative cuttings of floricultural plants has been of great interest for many years. Curtis in 1918 (6) found that 1-2% potassium permanganate solution promoted rooting of cuttings, while inorganic nutrient solutions had no effect. Van der Lek (15,16) showed that the presence of leaves promoted root formation at the base of a cutting. This report stimulated investigations on the role of hormones in the initiation of roots. F. W. Went (34) extracted heteroauxin, the root-forming hormone, which he termed rhizocaline, from leaves and germinating barley which, when applied to cuttings, promoted the development of new roots. F. A. F. C. Went (33) investigated the root-forming substance in *Bryophyllum calycinum*.

These reports encouraged plant physiologists in the 1930's to study the effects of auxins and their methods of application on the root formation in the propagation of ornamental plants. In the span of one decade, studies were performed using indole-3-acetic acid (5,8,12,17,22,28,36, 37,38), alpha-naphthaleneacetic acid (12,28,30,37,38), 3-indolebutyric acid (12,13,14,22,30,31,32,37,38), indole-3-propionic acid (1,11,27,37,38), and phenylacetic acid

(36,37,38). Indolebutyric acid and naphthaleneacetic acid were found to be most effective. While most of this work involved prolonged immersion of the base of cuttings in dilute water solutions of varying concentrations of auxins for six hours to two days, some experimentation was done with lanolin pastes containing auxins (11,28,29,37,38). These pastes applied to the base of cuttings were found to be inferior to water solutions of auxins (12). Quick dipping of the bases into concentrated solutions was shown superior over all other methods of application (17). Auxins mixed into talcs were just as effective as water solutions (9,12,20,25,26). In addition, powder treatments possess definite advantages such as greater ease of application and safe use, in that disease organisms are not spread as readily.

Since the extensive work with auxins and application methods, researchers have explored other factors affecting cutting propagation of poinsettia. Fertilizer misting (18, 19), drenches of fungicides (2,10), treatment combinations of auxins and fungicides (7), cutting size (35), and type of growing medium (3) have been studied more recently. The effects of plant growth regulators on the propagation of poinsettia have been a topic of recent interest (4,24).

These studies were undertaken to evaluate the effectiveness of various chemicals on the rooting of vegetative cuttings of two poinsettia cultivars.

Materials and Methods

Vegetative terminal cuttings of poinsettia, *Euphorbia pulcherrima* Willd., cvs. Dark Red Annette Hegg and Mikkel White Rochford, were cut uniformly to 8.75 cm. For liquid treatments, the cuttings were dipped 2.5 cm into the solution for fifteen seconds; for powder treatments, cuttings were dipped and excess powder removed by tapping the side of the cutting. Cuttings then were placed into a 15 cm deep sand medium in a raised propagation bench, under intermittent mist. Thermostatically controlled bottom heat of 22-25°C was maintained in the sand medium. Greenhouse air temperatures throughout the studies ranged between 21 and 24°C in the winter and 21 and 27°C in the summer. During the winter, photoperiodic lighting was employed from 10 PM to 2 AM. There were five cuttings in each treatment per variety in each replication. Number of replications varied from 2 to 4 throughout the experiments. After twenty days, cuttings were harvested and the number of roots and root fresh and dry weights were recorded. The results were analyzed statistically with analysis of variance obtained for each rooting variable, and mean separation was done by Tukey's H.S.D.

The chemicals employed, their chemical name, the source, and the concentrations used are shown in Table 1. The dates for each experiment are in the table headings.

Table 1. Growth regulators and auxins tested for stimulating rooting of poinsettia cuttings.

Commercial name	Chemical name	Company supplying	Concentration
Alar-85	Succinic acid-2,2-dimethyl-hydrazide	Uniroyal	500,1000,2500, 5000 ppm
A-Rest	α-cyclopropyl-α-(4-methoxy-phenyl)-5-pyrimidinemethanol	Eli Lilly	5,10,20 ppm
Atonik	Mono-nitro-guaiacol Na	Asahi	1:12,000,1:6000, 1:3000
B-Nine	Succinic acid-2,2-dimethyl-hydrazide	Uniroyal	500,1000,2500, 5000 ppm
CHE 9064	(undisclosed)	Chemagro	1000,2000,4000 ppm
Chlorflurenol	2-chloro-9-hydroxyfluorene-9-carboxylic acid	U.S. Borax Research	1,10,20 ppm
Chloromone	Indole naphthylacetamine	Chlorophyll Corp. of America	750 ppm
CPTA	2-(4-chlorophenythio)-triethyl-amino hydrochloride	AmChem	1,10,100,1000 ppm
CUTstart	(undisclosed)	Vitamin Institute	No.1 powder
Cycocel	(2-chloroethyl)thimethyl-ammonium chloride	American Cyanamid	100,500 ppm
Ethrel	(2-chloroethyl)phosphonic acid	AmChem	50,100,150,250, 500,1000 ppm
H-1244	(undisclosed)	American Cyanamid	500,1000,2000 ppm
HOL 0715	(undisclosed)	Chemagro	1000,2000,4000 ppm
Hormex	3-indolebutyric acid	Brooker	No.1 powder
Hormodin	3-indolebutyric acid	Merck	No.1, No.2 powder
IBA	3-indolebutyric acid	Eastman Kodak	500,1000,2000 ppm

Table 1 (cont'd.)

Commercial name	Chemical name	Company supplying	Concentration
Jiffy Grow	2-naphthaleneacetic acid 3-indolebutyric acid	G and W Products	1000 ppm
NIA 10637	Ethyl hydrogen 1-propyl-phosphonate	Niagara	50,100 ppm
NIA 10656	1-propylphosphonic acid	Niagara	25,50 ppm
RH 531	Sodium-1-(para-chlorophenyl)-1, 2-dihydro-4-dimethyl-2-2-oxonicotinate	Rohm and Haas	100,500,1000 ppm
Rootone F	1-naphthaleneacetimide 2-methyl-1-naphthalene acetic acid 2-methyl-1-naphthalene acetamide 3-indolebutyric acid, and thiram	AmChem	powder
Rutin	Quercetin-3-rutinoside	Sigma	200,400,600 ppm
TH 6239	5,7-dichloro-4-ethoxycarbonyl-methoxy-2,1,3-benzothiadiazole	Thompson-Hayward	1,5,10,20,40 ppm
TH 6240	6-chloro-5-ethoxycarbonyl-methoxy-2,1,3-benzothiadiazole	Thompson-Hayward	1,5,10,20,40 ppm
TH 6241	5-chloro-6-ethoxycarbonyl-methoxy-2,1,3-benzothiadiazole	Thompson-Hayward	1,5,10,20,40 ppm

Results

In eight experiments, various chemicals were found to stimulate root formation and growth. A treatment by variety interaction was not observed for any of the experiments, thus the data presented are the mean of both varieties. The first study showed that Jiffy Grow at 1000 ppm (the recommended rate) and Hormodin No. 2 induced a highly significant increase in number of roots over untreated cuttings (99.7 and 108.6 versus 46.6, Table 2). Hormodin No. 2 significantly increased fresh and dry weights of roots. Fresh weight per root was nonsignificant for all treatments. B-Nine at 1000 ppm and 3-indolebutyric acid at 500 ppm increased fresh root weight over control cuttings, although nonsignificantly. No significant increase in rooting was observed with Hormex No. 1 and Ethrel at the concentrations used.

The results of a more extensive survey of experimental chemicals and auxins are presented in Table 3. Jiffy Grow at 1000 ppm again gave the greatest root promotion. The 90.5 mean number of roots was highly significant over that for the untreated cuttings (44.8). Hormodin No. 2 produced a mean root number of 70.0 which was higher than the control but was not significant as was observed in the first study. No treatment resulted in a significant increase in fresh and dry root weight or fresh weight per root, although Jiffy Grow caused large increases over the control. CHE 9064 at 200 ppm and HOL 0715 at 4000 ppm increased the fresh and

Table 2. The effect of B-Nine, Hormodin No. 2, Hormex No. 1, Ethrel, IBA, and Jiffy Grow on stimulating rooting of poinsettia cuttings. Study conducted from August 6 to August 26.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
B-Nine	1000 ppm	66.2	1.229	0.108	0.0185
	2500	56.0	1.026	.101	.0191
	5000	48.6	0.907	.080	.0182
Hormodin No. 2		108.6	1.601	.135	.0175
Hormex No. 1		43.8	0.793	.076	.0184
Ethrel	250	49.4	1.054	.085	.0212
	500	39.9	0.736	.066	.0202
	1000	47.1	0.864	.080	.0191
I.B.A.	500	46.5	1.293	.095	.0269
	1000	59.0	1.007	.094	.0164
	2000	59.0	0.743	.067	.0138
Jiffy Grow	1000	99.7	1.357	.123	.0140
Check		46.6	0.871	.072	.0199
H.S.D. (5%)		27.7	0.716	.061	N.S.
(1%)		31.7	0.819	.070	N.S.

Table 3. The effect of Jiffy Grow, Hormodin No. 2, Ethrel, B-Nine, Alar, Cycocel, A-Rest, and several experimental chemicals on stimulating rooting of poinsettia cuttings. Study was conducted from September 16 to October 6.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
Jiffy Grow	1000 ppm	90.5	1.410	0.121	0.0152
Hormodin No. 2		70.0	0.964	.081	.0131
Ethrel	50	49.7	0.758	.064	.0147
	100	40.2	0.650	.051	.0141
	150	47.4	0.844	.066	.0187
B-Nine	500	43.4	0.718	.054	.0157
	1000	40.6	0.738	.071	.0162
	2500	49.0	0.719	.067	.0141
Alar-85	500	45.0	0.814	.068	.0168
	1000	50.3	0.845	.067	.0164
	2500	41.0	0.520	.063	.0114
Cycocel	100	53.7	0.793	.064	.0157
	500	48.6	0.646	.055	.0130
A-Rest	5	50.4	1.050	.088	.0196
	10	47.2	0.893	.084	.0192
	20	47.2	0.863	.082	.0170
CHE 9064	1000	37.8	0.966	.098	.0243
	2000	41.7	1.137	.107	.0261
	4000	37.3	0.616	.067	.0151
HOL 0715	1000	41.8	0.977	.086	.0230
	2000	56.5	1.034	.088	.0182
	4000	59.4	1.159	.098	.0190
NIA 10637	50	47.0	0.876	.077	.0193
	100	43.8	0.631	.063	.0130
NIA 10656	25	44.8	0.815	.071	.0167
	50	50.1	0.760	.068	.0151
Check		44.8	0.736	.066	.0167
H.S.D. (5%)		25.4	0.829	.072	N.S.
(1%)		29.1	N.S.	N.S.	N.S.

dry root weights but it was not a significant one. A-Rest at 5 ppm stimulated rooting slightly. None of the other chemicals tested promoted rooting as measured by the different variables.

Chloromone at 750 ppm (the recommended rate) and CUTstart treatments resulted in the highest root inducement in the third study, although no values were statistically significant over the untreated cuttings (Table 4). Rutin and H-1244 at the concentrations tested showed no stimulation of rooting. RH 531 at 500 ppm produced the highest root number and dry root weight. Chloromone caused the greatest fresh weight per root, but none of the treatments increased this variable over the control.

In the subsequent study (Table 5), Rootone F (with Thiram) resulted in the highest rooting response for all variables, but none were significantly higher than untreated cuttings. RH 531 at 500 ppm and CUTstart resulted in less rooting than the control. Likewise, Chloromone showed no rooting stimulation.

Additional experimental chemicals, Atonik, CPTA, and chlorflurenol were studied in the fifth experiment (Table 6). A check solution of 5% methanol was included since chlorflurenol was first dissolved in this solution. The combination of a 15-second dip in Jiffy Grow followed by Hormodin No. 2 powder gave the greatest root number, fresh and dry root weights. No treatment gave results significantly higher than the untreated check. Jiffy Grow alone

Table 4. The effect of Rutin, CUTstart, Chloromone, RH 531, and H-1244 on stimulating rooting of poinsettia cuttings. Study was conducted from April 27 to May 18.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
Rutin	200 ppm	49.3	1.392	0.173	0.0286
	400	47.4	1.390	.171	.0285
	600	48.0	1.386	.171	.0291
CUTstart		52.0	1.688	.182	.0316
Chloromone	750	44.7	1.767	.185	.0384
RH 531	100	50.2	1.346	.170	.0264
	500	52.1	1.453	.182	.0275
	1000	35.1	0.832	.106	.0197
H-1244	500	44.8	1.238	.139	.0278
	1000	47.0	1.289	.151	.0296
	2000	49.0	1.434	.161	.0304
Check		42.0	1.299	.145	.0315
H.S.D. (5%)		15.3	0.752	N.S.	.0143

Table 5. The effect of CUTstart, Chloromone, RH 531, and Rootone F on stimulating rooting of poinsettia cuttings. Study was conducted from June 22 to July 12.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
CUTstart		33.4	0.621	0.060	0.0150
Chloromone	750 ppm	46.2	0.862	.088	.0164
RH 531	500	27.8	0.535	.051	.0167
Rootone F		51.8	1.072	.093	.0209
Check		39.4	0.839	.086	.0209
H.S.D. (5%)		25.5	N.S.	N.S.	N.S.
(1%)		30.1	N.S.	N.S.	N.S.

Table 6. The effect of CPTA, Atonik, Chlorflurenol, Jiffy Grow, Hormodin No. 2, and Chloromone on stimulating rooting of poinsettia cuttings. Study was conducted from July 21 to August 10.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
CPTA	1 ppm	35.2	1.006	0.093	0.0268
	10	37.2	1.044	.105	.0286
	100	35.6	0.856	.081	.0240
	1000	36.2	0.965	.092	.0251
Atonik	1:12000	38.2	1.073	.098	.0294
	1:6000	35.8	0.852	.088	.0223
	1:3000	37.4	1.023	.104	.0296
Chlorflurenol	1	34.9	0.954	.102	.0270
	10	37.3	0.945	.096	.0270
	20	38.1	0.978	.100	.0257
Jiffy Grow	1000	44.1	1.458	.135	.0343
Jiffy Grow & Hormodin No. 2	1000	52.7	1.493	.137	.0292
Hormodin No. 2		43.6	1.233	.118	.0281
Chloromone	750	41.1	1.208	.105	.0296
Check-methanol		34.3	0.895	.081	.0256
Check		40.3	1.084	.102	.0279
H.S.D. (5%)		15.1	0.549	.050	.N.S.
(1%)		17.3	0.628	.057	N.S.

produced similar results as when used in combination with Hormodin No. 2. No root stimulation was observed with Atonik, CPTA, or chlorflurenol.

The experimental benzothiadiazole chemicals, TH 6239, 6240, and 6241 were compared against untreated cuttings and cuttings dipped for 15 seconds in 5% methanol, since the former were dissolved first in methanol. Due to a shortage of cuttings, cv. Annette Hegg Supreme was substituted for Dark Red Annette Hegg. No significant increase in rooting over the controls was found with any of the concentrations of the three chemicals (Table 7). Although results were nonsignificant, TH 6240 and TH 6241, both at 20 ppm resulted in the greatest overall root inducement and growth.

A study was conducted with Jiffy Grow at 1000 ppm and Chloromone at 750 ppm in combination with the auxin-containing powders: Hormodin No. 2, Rootone F, and CUTstart. Both Jiffy Grow and Chloromone in combination with Hormodin No. 2 resulted in the greatest number of roots, highly significantly greater than the untreated cuttings (Table 8). The greatest increase in dry root weight, although nonsignificant, was produced also by these two combination treatments. The greatest fresh root weight was found in the combination of Chloromone and CUTstart, but this and other increases were not significant over the check. No differences were found in fresh weight per root. Neither the combination of Hormodin No. 2 and Fermate nor Hormodin No. 3 stimulated rooting.

Table 7. The effect of TH 6239, TH 6240, and TH 6241 on stimulating rooting of poinsettia cuttings. Study was conducted from September 18 to October 9.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
TH 6239	1 ppm	32.3	0.420	0.054	0.0121
	5	42.8	.577	.082	.0123
	10	33.8	.682	.090	.0158
	20	32.5	.344	.048	.0094
	40	41.8	.642	.086	.0142
TH 6240	1	38.1	.476	.063	.0119
	5	32.4	.505	.059	.0148
	10	34.8	.514	.094	.0116
	20	44.4	.798	.088	.0174
	40	40.1	.593	.075	.0136
TH 6241	1	42.4	.466	.065	.0105
	5	36.7	.495	.071	.0132
	10	38.8	.524	.069	.0130
	20	40.5	.749	.095	.0184
	40	36.1	.501	.065	.0136
Check-methanol		31.5	.540	.058	.0172
Check		27.8	.352	.046	.0089
H.S.D. (5%)		N.S.	N.S.	N.S.	N.S.
(1%)		N.S.	N.S.	N.S.	N.S.

Table 8. The effect of liquid and powder combination treatments on stimulating rooting of poinsettia cuttings. Study was conducted from December 14 to January 3.

Treatment	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
Jiffy Grow & Hormodin	38.3	0.765	0.132	0.0234
Jiffy Grow & Rootone F	26.5	.790	.119	.0281
Jiffy Grow & CUTstart	32.9	.765	.130	.0238
Jiffy Grow & Chloromone	31.0	.696	.129	.0220
Chloromone & Hormodin	38.9	.708	.137	.0185
Chloromone & Rootone F	32.5	.786	.130	.0250
Chloromone & CUTstart	31.8	.819	.124	.0249
Hormodin No. 2	31.5	.722	.116	.0246
Hormodin No. 3	24.4	.508	.084	.0212
Hormodin No. 2 & Fermate	27.0	.681	.120	.0258
Check	19.4	.574	.116	.0277
H.S.D. (5%)	15.5	N.S.	N.S.	N.S.
(1%)	18.3	N.S.	N.S.	N.S.

Table 9. The effect of method of application of Hormodin No. 2 on stimulating rooting of poinsettia cuttings. Study was conducted from January 11 to January 31.

Treatment	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
Powder dip	36.8	0.576	0.072	0.0181
Water dip, then powder dip	37.6	.529	.076	.0140
Powder spray	48.3	.548	.062	.0107
Water dip, then powder spray	35.8	.527	.067	.0140
Check	19.1	.309	.038	.0155
H.S.D. (5%)	19.9	N.S.	N.S.	.0065
(1%)	26.7	N.S.	N.S.	N.S.

The methods of applying Hormodin No. 2 were tested (Table 9). Methods used were: dipping of basal end of cuttings into powder, dipping into water followed by powder, spraying of powder onto basal end of cuttings, and dipping into water followed by spraying of powder onto basal ends. Only the powder spray of Hormodin No. 2 resulted in a significant increase in root number over untreated cuttings. The other methods produced a nonsignificant increase in root number. Dipping into powder produced the greatest fresh root weight and fresh weight per root, but none of the root weight values were significantly greater than those of the check. The four application methods were equally effective in promoting rooting.

Discussion

B-Nine at concentrations between 1000 and 5000 ppm has been reported to stimulate rooting of chrysanthemum, geranium, poinsettia, and carnation cuttings, with 2500 ppm giving the optimum results (23,24). Basal dip treatments produced greater fresh and dry root weights and increased the number of roots. Cycocel at 1000 and 2500 ppm inhibited root initiation and development (4). In our study, B-Nine at 1000 ppm increased fresh root weight over untreated cuttings, although the observed effect was nonsignificant statistically. Additional studies employing the same B-Nine concentrations did not result in a consistent stimulation.

A combination treatment of IBA and B-Nine did not provide an increase in root weights and numbers over B-Nine treatment alone with chrysanthemum and geranium cuttings (23). B-Nine at 1250 ppm and Hormex No. 1 (0.1% IBA) surpassed B-Nine alone in number of roots and fresh weight of poinsettia (4). It was also found that post-drench treatments of Cycocel at 100 ppm and Hormex greatly enhanced root number and fresh weight. We observed that Hormodin No. 2 (0.3% IBA) following a 15-second dip in Jiffy Grow at 1000 ppm produced more roots and greater root weights than either treatment alone, although the increases were statistically nonsignificant. A significant increase in root number over untreated cuttings was found with the combination treatments of Jiffy Grow at 1000 ppm and Hormodin No. 2 and with Chloromone at 750 ppm and Hormodin No. 2.

Cycocel at 1000 and 2500 ppm retarded root growth of poinsettia (24), but at 100 ppm as a soil drench produced increases in poinsettia rooting variables (4). Cycocel at 100 and 500 ppm used as a basal dip in our studies did not stimulate rooting over untreated cuttings. A-Rest at 125 ppm and NIA 10637 at 1000 ppm were recently reported to induce root growth in difficult-to-root azalea cultivars (21). A-Rest at concentrations between 5 and 25 ppm, and NIA 10637 at 50 and 100 ppm did not produce greater root weights or number of roots than untreated cuttings in this work with poinsettia.

Since these experiments were conducted over a two year period, some inconsistencies of the results can be attributed to the environmental conditions due to the season of the year. Experiments whose results are presented in Tables 3, 7, 8, and 9 were conducted during late fall and winter. Lower light intensities and air temperatures may account for the lower number of roots and root weights. However, in all experiments, there was no significant difference in fresh weight per root between untreated and treated cuttings. Thus, an increase in root fresh weight accompanied the increase in root number, resulting in a higher quality rooted cutting. The use of these chemicals to increase root number therefore does not cause a reduction in the weight and size of the individual roots.

Although the results from several experiments were statistically nonsignificant, increases by many treatments should not be regarded as being unobserved. For example, increases of 103% and 81% in root number over control cuttings as observed with Rootone F and Chloromone certainly indicate a benefit in rooting with their use.

Our studies indicate that auxin compounds are the best promoters of rooting of poinsettia cuttings. Jiffy Grow (0.5% NAA and 0.5% IBA) and Hormodin No. 2 (0.3% IBA) applied separately and in combination increased root number and root fresh and dry weights the greatest of all chemicals tested. Chloromone, which contains an auxin-like compound, also enhanced rooting when applied in combination with Hormodin No. 2. Hence, we believe that auxin-containing chemicals, which are widely used on a commercial basis, should be included in research studies using experimental growth regulators for testing the stimulation of rooting.

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PAPER II

THE RESPONSE OF POINSETTIA CULTIVARS TO AUXINS IN ROOT PROMOTION OF CUTTINGS

Introduction

The effects of growth regulators and auxins on the propagation of cuttings of floricultural plants have been studied for many years. F. A. F. C. Went (25) developed the concept that root-forming substances were produced in the leaves of plants and cuttings. F. W. Went (26) isolated an auxin, indole-3-acetic acid, from barley coleoptile tips, and applied the extract to bases of cuttings and observed a stimulation in root formation.

Following these early studies, plant physiologists in the 1930's investigated the effects of auxins and application methods on the rooting of many horticultural plants. Researchers have studied root-inducing activity of indole-3-acetic acid (4,9,12,15,27,28), alpha-naphthaleneacetic acid (9,22,27,28), 3-indolebutyric acid (9,10,11,15,22,23,24,27,28), phenylacetic acid (27,28), and indole-3-propionic acid (1,8,20,27,28). The most effective auxins are indolebutyric acid and naphthaleneacetic acid. Application methods of soaking bases of cuttings in dilute auxin solutions for up to two days (8,9,10,13,28), dipping in lanolin pastes containing auxins (8,21,27,28), quick dipping into concentrated solutions (17), and the use of talcs (6,9,14,17,18) have been studied. Fifteen second dips into concentrated aqueous solutions of auxins were shown superior to all other application methods, except powders, which have been shown to be as effective and less likely to spread disease organisms.

Since the extensive work with auxins and application methods, the effects of growth regulators (3,16) and fungicides (2,5,7) on the propagation of poinsettia have been investigated. Preliminary studies which we conducted demonstrated that auxin-containing substances are superior to growth regulators in root promotion.

This study was undertaken to establish the response of poinsettia cultivars to several auxins, when used to stimulate rooting of cuttings.

Materials and Methods

Vegetative terminal cuttings of poinsettia, *Euphorbia pulcherrima* Willd., were cut uniformly to 8.75 cm. The nine poinsettia cultivars used were 'Eckespoint C-1 Red', 'Mikkel Improved Rochford', 'Mikkel White Rochford', 'Paul Mikkelsen', 'Dark Red Annette Hegg', 'Annette Hegg Supreme', 'Ecke White', 'Pink Annette Hegg', and 'Marble Annette Hegg'. The basal 2.5 cm of five cuttings was dipped for 15 seconds for liquid treatments or was dipped singly into the powder treatments and tapped lightly to remove the excess. Chemicals tested were Jiffy Grow (1000 ppm auxins), Chloromone (750 ppm auxin-like substance), Hormodin No. 2 (3000 ppm IBA), and Rootone F (1700 ppm auxins) (Table 1).

Table 1. Auxin-containing chemicals tested for stimulating rooting of poinsettia cuttings.

Commercial name	Chemical name	Company supplying	Concentration
Chloromone	Indole naphthylacetamine	Chlorophyll Corp. of America	750 ppm
Hormodin	3-indolebutyric acid	Merck	No. 2 powder
Jiffy Grow	2-naphthaleneacetic acid	G and W Products	1000 ppm
	3-indolebutyric acid		
Rootone F	1-naphthalene acetamide	AmChem	powder
	2-methyl-1-naphthalene acetic acid		
	2-methyl-1-naphthalene acetamide		
	3-indolebutyric acid thiram		

These auxin-containing substances resulted in the greatest root number, fresh and dry root weights in previous studies. For each experiment, there were two to four replications per variety, each with five cuttings. Cuttings were rooted under intermittent mist in a raised propagation bench filled with coarse sterilized sand to a depth of 15 cm. Thermostatically controlled bottom heat of 22-25°C was maintained in the sand. Greenhouse air temperatures during the winter study ranged between 21 and 24°C; the summer study between 21 and 27°C. During the late winter propagation study, photoperiodic lighting was employed from 10 PM to 2 AM. After 22 days, cuttings were dug and the number of roots and root fresh and dry weights were recorded. The results were analyzed statistically with analysis of variance obtained for each rooting variable, and mean separation was done by Tukey's H.S.D.

Results

The effects of the chemicals on root stimulation from the first study conducted in the late winter (March) are shown in Table 2. Dips in Jiffy Grow at 1000 ppm followed by Hormodin No. 2 highly significantly (1% level) increased the number of roots and root fresh and dry weights in comparison to untreated cuttings. This combination treatment produced a number of roots highly significant over Jiffy Grow and Hormodin when each was applied separately. Both Jiffy Grow and Hormodin separately caused significant

Table 2. Response of all poinsettia cultivars to auxins. Study was conducted from March 18 to April 10.

Treatment	Concn.	Mean no. roots	Mean fresh wt.(g)	Mean dry wt.(g)	Mean fresh wt. per root
Jiffy Grow	1000 ppm	26.6	1.366	0.155	0.0489
Hormodin	No. 2	36.1	1.299	0.152	.0355
Jiffy Grow & Hormodin	1000 No. 2	55.7	1.508	0.187	.0296
Check		13.7	0.765	0.090	.0374
H.S.D. (5%)		11.4	0.314	0.067	.0118
(1%)		13.9	0.385	0.082	.0145

increases in root number and fresh weight over untreated cuttings.

Poinsettia cultivars tested are indicated in Table 3, together with the mean results for the variables measured. C-1 Red and Annette Hegg Supreme produced the least number of roots and root fresh and dry weights, while Dark Red Annette Hegg and M. White Rochford produced the greatest values for these variables. Fresh weight per root was greatest with cv. M. White Rochford.

The combination treatment of Jiffy Grow at 1000 ppm and Hormodin No. 2 stimulated the greatest number of roots and root fresh and dry weights for all cultivars except Annette Hegg Supreme and M. Imp. Rochford (Table 4 and Figures 1 and 2), and resulted in significant increases in rooting over Jiffy Grow and Hormodin when each was applied separately. These results are highly significant when compared to untreated cuttings. Cultivars Annette Hegg Supreme and M. Imp. Rochford responded similarly to the auxin treatments, with separate applications producing rooting values as great as the combination treatment. Overall, Hormodin No. 2 tended to produce a greater number of roots although lower fresh and dry root weights than Jiffy Grow at 1000 ppm on all cultivars.

The results of the late summer (September) cultivar rooting study are indicated in Tables 5, 6 and 7. With cultivars combined, the dual treatment of Jiffy Grow at 1000 ppm and Hormodin No. 2 was the only treatment

Table 3. Response of poinsettia cultivars to all root promoters in the trial conducted from March 18 to April 10.

Variety	No. roots	Fresh wt.(g)	Dry wt.(g)	Fresh wt. per root
M. Improved Rochford	38.5	1.374	0.166	0.0384
Paul Mikkelsen	34.5	1.205	0.134	.0390
Dark Red Annette Hegg	47.8	1.725	0.224	.0420
M. White Rochford	40.1	1.741	0.243	.0488
C-1 Red	17.9	0.481	0.056	.0232
Annette Hegg Supreme	17.9	0.818	0.073	.0444
Ecke White	27.6	0.845	0.088	.0338
H.S.D. (5%)	14.6	0.404	0.086	.0151
(1%)	17.6	0.488	0.103	.0182

Table 4. The rooting response of poinsettia cultivars to auxin-containing chemicals. Study was conducted from March 18 to April 10.

Treatment	Concn.	Dark Red Annette Hegg				Mikkel White Rochford			
		No. rts.	Fresh wt. (g)	Dry wt. (g)	Fr. wt. per rt.	No. rts.	Fresh wt. (g)	Dry wt. (g)	Fr. wt. per rt.
Jiffy Grow	1000	39.9	2.240	0.289	0.0551	33.1	1.666	0.224	0.0550
Hormodin	No.2	52.5	1.766	.212	.0349	36.9	2.008	.233	.0556
Jiffy Grow & Hormodin	1000 No.2	79.1	1.934	.235	.0274	72.3	2.293	.325	.0336
Check		26.2	1.345	.199	.0523	27.7	1.357	.171	.0513
		Annette Hegg Supreme				Mikkel Improved Rochford			
Jiffy Grow	1000	19.5	1.107	0.107	0.0582	33.8	1.903	0.191	0.0545
Hormodin	No.2	24.7	1.094	.095	.0433	47.4	1.730	.262	.0374
Jiffy Grow & Hormodin	1000 No.2	23.3	0.905	.075	.0381	53.5	1.102	.145	.0230
Check		7.6	0.225	.022	.0242	28.9	1.156	.132	.0412

Table 4 (cont'd.)

Treatment	Concn.	C-1 Red No. rts.	C-1 Red Fresh wt. (g)	C-1 Red Dry wt. (g)	C-1 Red Fr. wt. per rt.	Ecke White No. rts.	Ecke White Fresh wt. (g)	Ecke White Dry wt. (g)	Ecke White Fr. wt. per rt.
Jiffy Grow	1000	14.5	0.511	0.079	0.0332	19.0	0.802	0.073	0.0362
Hormodin	No.2	20.0	0.404	.051	.0187	38.2	1.056	.104	.0286
Jiffy Grow & Hormodin	1000 No.2	36.2	1.015	.109	.0283	53.7	1.396	.162	.0277
Check		4.3	0.120	.010	.0147	7.0	0.302	.029	.0387

Treatment	Concn.	Paul Mikkelsen No. rts.	Paul Mikkelsen Fresh wt. (g)	Paul Mikkelsen Dry wt. (g)	Paul Mikkelsen Fr. wt. per rt.
Jiffy Grow	1000	26.3	1.334	0.121	0.0551
Hormodin	No.2	32.9	0.963	.107	.0297
Jiffy Grow & Hormodin	1000 No.2	71.5	1.910	.260	.0295
Check		21.0	0.849	.069	.0394
H.S.D. (5%)		14.6	0.404	.086	.0151
(1%)		17.6	0.488	.103	.0182

Figure 1. Mean number of roots per cutting of poinsettia cultivars in response to auxin treatments. Study was conducted from March 18 to April 10.

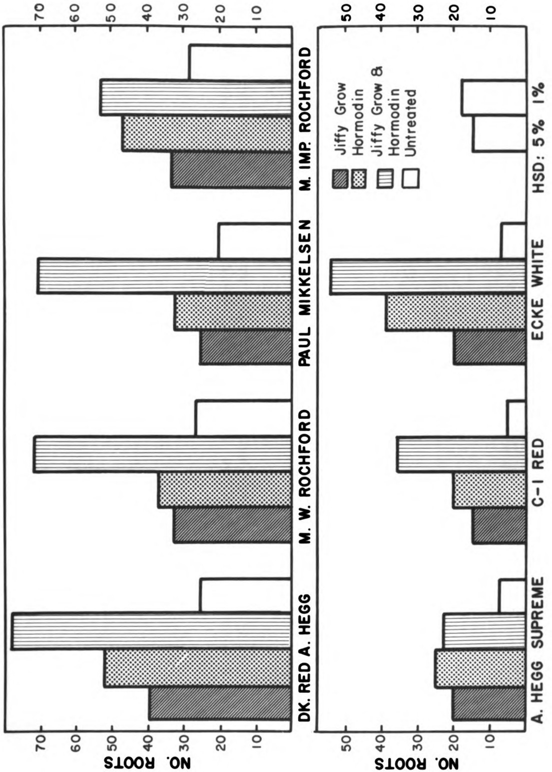

NO. ROOTS
70
60
50
40
30
20
10
DK. RED A. HEGG
M. W. ROCHFORD
PAUL MIKKELSEN
M. IMP. ROCHFORD
NO. ROOTS
50
40
30
20
10
A. HEGG SUPREME
C-1 RED
ECKE WHITE
HSD: 5% 1%
Jiffy Grow
Hormodin
Jiffy Grow &
Hormodin
Untreated

Figure 2. Mean root fresh weight per cutting of poinsettia cultivars in response to auxin treatments. Study was conducted from March 18 to April 10.

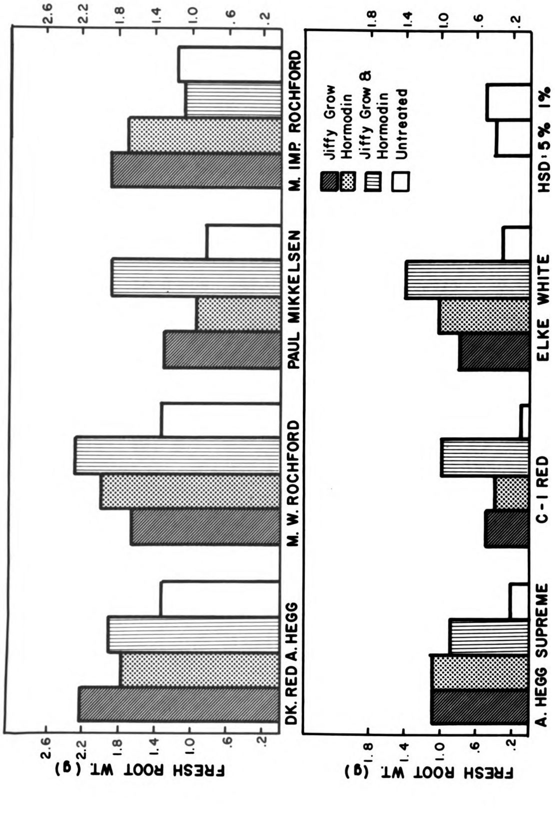

FRESH ROOT WT. (g)
2.6
2.2
1.8
1.4
1.0
.6
.2
DK. RED A. HEGG
M. W. ROCHFORD
PAUL MIKKELSEN
M. IMP. ROCHFORD
A. HEGG SUPREME
C-I RED
ELKE WHITE
HSD: 5% 1%
Jiffy Grow
Hormodin
Jiffy Grow &
Hormodin
Untreated

Table 5. Response of all poinsettia cultivars to auxins. Study was conducted from September 29 to October 19.

Variety	Concn.	No. roots	Fresh wt.(g)	Dry wt.(g)	Fresh wt. per root
Jiffy Grow	1000 ppm	40.0	0.772	0.075	0.0211
Jiffy Grow & Hormodin	1000 No. 2	54.6	0.764	.085	.0131
Hormodin	No. 2	42.7	0.654	.063	.0161
Chloromone	750	37.1	0.674	.083	.0188
Chloromone & Hormodin	750 No. 2	50.2	0.706	.074	.0136
Rootone F		32.3	0.697	.064	.0209
Check		24.7	0.433	.047	.0168
H.S.D. (5%)		18.8	N.S.	N.S.	.0084
(1%)		22.8	N.S.	N.S.	N.S.

Table 6. Response of poinsettia cultivars to all root promoters in the trial conducted from September 29 to October 19.

Variety	No. roots	Fresh wt.(g)	Dry wt.(g)	Fresh wt. per root
C-1 Red	59.5	0.838	0.082	0.0151
Annette Hegg Supreme	34.8	0.618	.071	.0183
M. Improved Rochford	36.2	0.696	.069	.0188
Pink Hegg	34.3	0.651	.069	.0191
Marble Hegg	36.2	0.554	.059	.0150
H.S.D. (5%)	14.7	N.S.	N.S.	N.S.
(1%)	18.0	N.S.	N.S.	N.S.

Table 7. The rooting response of poinsettia cultivars to auxin-containing chemicals. Study was conducted from September 29 to October 19.

Treatment	Concn.	Marble Hegg No. rts.	Marble Hegg Fresh wt. (g)	Marble Hegg Dry wt. (g)	Marble Hegg Fr. wt. per rt.	Pink Hegg No. rts.	Pink Hegg Fresh wt. (g)	Pink Hegg Dry wt. (g)	Pink Hegg Fr. wt. per rt.
Jiffy Grow	1000	22.3	0.358	0.039	0.0162	31.1	0.845	0.089	0.0281
Hormodin	No.2	44.7	0.665	.062	.0134	19.9	.526	.052	.0209
Jiffy Grow & Hormodin	1000 No.2	40.6	0.601	.071	.0136	65.7	.967	.091	.0147
Chloromone	750	51.4	1.076	.108	.0219	27.2	.480	.068	.0174
Chloromone & Hormodin	750 No.2	42.6	0.447	.054	.0103	53.2	.888	.088	.0174
Rootone F		28.4	0.261	.031	.0088	26.4	.608	.061	.0218
Check		23.6	0.468	.047	.0193	16.4	.247	.032	.0131

Treatment	Concn.	Annette Hegg Supreme No. rts.	Annette Hegg Supreme Fresh wt. (g)	Annette Hegg Supreme Dry wt. (g)	Annette Hegg Supreme Fr. wt. per rt.	Mikkel Improved Rochford No. rts.	Mikkel Improved Rochford Fresh wt. (g)	Mikkel Improved Rochford Dry wt. (g)	Mikkel Improved Rochford Fr. wt. per rt.
Jiffy Grow	1000	47.9	0.865	0.083	0.0196	27.3	0.782	0.071	0.0275
Hormodin	No.2	34.5	.524	.057	.0143	36.9	.839	.078	.0220
Jiffy Grow & Hormodin	1000 No.2	38.6	.358	.074	.0079	45.7	.813	.084	.0164
Chloromone	750	31.3	.706	.084	.0247	29.8	.396	.065	.0122
Chloromone & Hormodin	750 No.2	50.6	.871	.085	.0172	44.1	.494	.048	.0104
Rootone F		20.3	.636	.067	.0278	41.2	1.003	.084	.0236
Check		20.6	.364	.048	.0166	28.7	.545	.054	.0196

Table 7 (cont'd.)

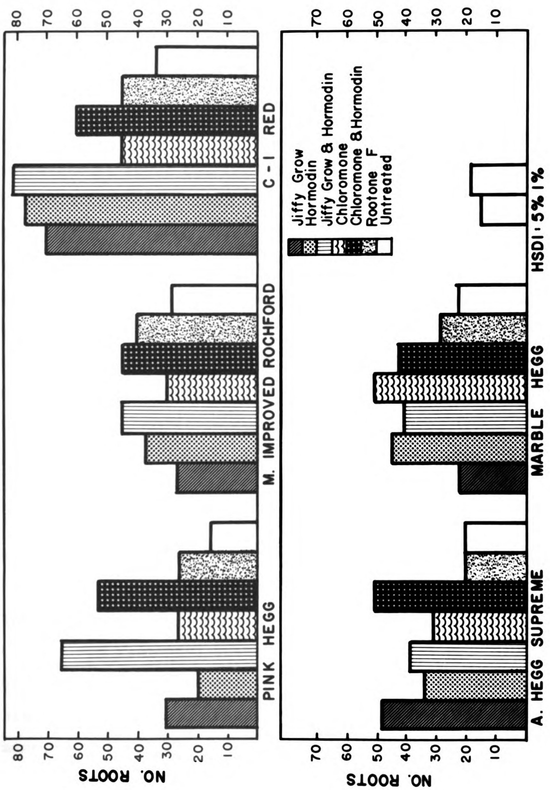
Treatment	Concn.	C-1 Red No. rts.	C-1 Red Fresh wt. (g)	C-1 Red Dry wt. (g)	C-1 Red Fr. wt. per rt.
Jiffy Grow	1000	71.2	1.008	0.094	0.0142
Hormodin	No.2	77.3	0.719	.066	.0099
Jiffy Grow & Hormodin	1000 No.2	82.4	1.081	.106	.0126
Chloromone	750	45.9	.711	.090	.0177
Chloromone & Hormodin	750 No.2	60.6	.828	.094	.0128
Rootone F		45.3	.978	.078	.0225
Check		34.0	.542	.051	.0157
H.S.D. (5%)		14.6	N.S.	N.S.	N.S.
(1%)		18.0	N.S.	N.S.	N.S.

significantly higher in root number than the untreated cuttings (Table 5). Neither Chloromone at 750 ppm nor the dual treatment of Chloromone and Hormodin, which were not tested in the first study, resulted in significant increases in root number. The increases in fresh and dry root weights and fresh weight per root were nonsignificant. The cultivar C-1 Red produced a significantly greater number of roots than the other cultivars tested (Table 6). Although C-1 Red produced a greater root fresh weight than the other cultivars, there was no significant difference in any root weight variable.

Marble Hegg responded best to treatment with Chloromone at 750 ppm alone (Table 7 and Figure 3). The number of roots was significantly greater than untreated cuttings with treatments of Hormodin No. 2, Jiffy Grow at 1000 ppm followed by Hormodin No. 2, Chloromone, and Chloromone followed by Hormodin No. 2, but no difference was found among these treatments. Jiffy Grow alone and Rootone F did not stimulate rooting. There was a definite, yet nonsignificant increase in fresh and dry root weights when cuttings of Marble Hegg were treated with Chloromone and Hormodin in combination.

The dual treatment of Jiffy Grow and Hormodin No. 2 increased root number, root fresh and dry weights the greatest in Pink A. Hegg. Jiffy Grow, Jiffy Grow plus Hormodin, and Chloromone plus Hormodin significantly increased root number over the check. The two combination

Figure 3. Mean number of roots per cutting of poinsettia cultivars in response to auxin treatments. Study was conducted from September 29 to October 19.


NO. ROOTS
80
70
60
50
40
30
20
10
PINK HEGG
M. IMPROVED ROCHFORD
C - I RED
NO. ROOTS
70
60
50
40
30
20
10
A. HEGG SUPREME
MARBLE HEGG
HSD .5% 1%
Jiffy Grow
Hormodin
Jiffy Grow & Hormodin
Chloromone
Chloromone & Hormodin
Rootone F
Untreated

treatments produced root numbers significantly greater than the other chemicals tested. Jiffy Grow more than doubled the fresh weight per root in Pink Hegg.

Chloromone and Hormodin in combination and Jiffy Grow increased root number, fresh and dry root weights in Annette Hegg Supreme. Root number was significantly increased by these two treatments and by Jiffy Grow and Hormodin in combination. The addition of Hormodin to Chloromone increased root number over treatment with Chloromone alone, but Hormodin in combination with Jiffy Grow did not produce a greater rooting response than separate treatment of the two chemicals. Rootone F and Chloromone increased fresh weight per root, although nonsignificantly.

The two combination treatments (Jiffy Grow with Hormodin and Chloromone with Hormodin) highly significantly increased root number in M. Imp. Rochford over untreated cuttings. Rootone F produced the largest fresh root weight, although it was a nonsignificant one. The two combination treatments did not stimulate rooting significantly over these three chemicals used separately on this cultivar.

C-1 Red responded best to the combination treatment of Jiffy Grow and Hormodin. Root number was increased significantly by all treatments except Rootone and Chloromone. Fresh and dry root weights tended to be greatest using Jiffy Grow, either alone or followed by Hormodin No. 2.

Discussion

Hormodin has been reported to stimulate rooting of poinsettia (13,22,23). Hormodin A (IBA) caused faster rooting of cuttings and increased the percentage of cuttings which rooted. IBA and NAA have been found to surpass all other auxins in root induction (9,10,18,19,22). Application methods of auxin-containing talcs or dipping in concentrated auxin solutions have proved to be superior to all other methods (10,12,17,18).

Recently, growth regulators have been tested for their effectiveness as root promoters of cuttings of poinsettia (3,16). B-Nine at 1250 and 2500 ppm, Cycocel at 100 ppm, and Benzyladenine (BA) at 0.5 ppm increased root number and fresh weight over untreated cuttings. When Hormex No. 1 (0.1% IBA) was used in combination with each of these chemicals, significantly greater number of roots and root fresh weight were observed (3).

Previous experiments indicated that auxin-containing substances exceeded experimental growth regulators in root promotion of poinsettia. In the winter study, the poinsettia cultivars tested responded similarly, with the combination treatment of Jiffy Grow at 1000 ppm and Hormodin No. 2 generally increasing rooting the best. Treatment with Chloromone alone or with Hormodin No. 2 were not included in this study. Treatment dips in Jiffy Grow followed by Hormodin No. 2 resulted in increased rooting over treatment with these substances separately, with the exception of Annette Hegg Supreme and M. Imp. Rochford. All cultivars tested in the winter with the exception of Annette Hegg Supreme produced the greatest number of roots after treatment with both Jiffy Grow and Hormodin, and the greatest fresh and dry root weights except for Annette Hegg Supreme and M. Imp. Rochford.

In the summer, the cultivars tested responded best to the combination treatments, with the exception of Marble Hegg, where Chloromone resulted in the best rooting. Jiffy Grow with Hormodin and Chloromone with Hormodin stimulated rooting to an equal degree, except with C-1 Red, where Jiffy Grow with Hormodin produced significantly greater root numbers and fresh and dry root weights than Chloromone with Hormodin. Rootone F did not significantly increase root number with any cultivar tested.

In comparing the two studies, lower root number, root fresh and dry weights were observed in the winter propagation study than in the summer. Lower greenhouse air temperatures and light intensities may account for this observation. In the winter, the addition of Hormodin No. 2 to treatment dips in Jiffy Grow at 1000 ppm caused a significant increase in rooting over these chemicals when applied separately for all cultivars tested except Annette Hegg Supreme, while in the summer this occurred only with cv. Pink Hegg. The dual treatment of Chloromone at 750 ppm and Hormodin No. 2 significantly increased root number in the summer study over separate applications of these chemicals only with cvs. Pink Hegg and Annette Hegg Supreme. Rootone F did not increase rooting in any cultivar. The results tend to show that the combination treatments are only beneficial in winter propagations. Separate applications of either Jiffy Grow, Chloromone, or Hormodin stimulate rooting in the summer to as great a degree as the combination treatments.

The cvs. Annette Hegg Supreme, Ecke White, and C-1 Red which produce the least amount of roots and lowest fresh weights when cuttings are not treated, responded best to the combination of Jiffy Grow and Hormodin No. 2. Root number and fresh weight were increased 750% over untreated cuttings of C-1 Red. The combination treatment increased root number 700% and root fresh weight 360% over untreated cuttings of Ecke White, and 200% and 300% respectively over control cuttings of Annette Hegg Supreme. The cultivars which produce fairly great root number and weights without auxins did not result in such great percent increases with the use of auxins. All poinsettia cultivars tested showed an increase in rooting response when pretreated with one of the auxin-containing substances.

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PAPER III

THE EFFECT OF AUXINS DURING ROOTING OF CUTTINGS AND ON SUBSEQUENT GROWTH AND FLOWERING OF POINSETTIA

Introduction

The promotion of rooting of cuttings by treatment with growth regulators and auxins has been studied on many horticultural plants. F. A. F. C. Went (23) reported that root-forming substances are produced in leaves of plants. F. W. Went (24) first isolated the auxin indole-3-acetic acid from barley coleoptiles and found that it promoted rooting of cuttings.

These studies encouraged researchers to study the response of cuttings to auxins and experimental plant growth regulators. Auxins found to stimulate rooting were indole-3-acetic acid (7,12,14,16,26,27), 3-indolebutyric acid (12,16,22,26,27), α-naphthaleneacetic acid (12,22,26, 27), indole-3-propionic acid (1,11,21,26,27), and phenylacetic acid (26,27). The auxins most effective in root promotion are IBA and NAA. Growth regulators such as B-Nine (succinic acid-2,2-dimethylhydrazide), Chlormequat, and Benzyladenine were reported to stimulate rooting of poinsettia cuttings (4,19). Root stimulation was observed by treatment with several fungicides (2,8,9). Studies which we conducted demonstrated that auxin-containing substances are superior to growth regulators in root promotion.

Although coarse sand has been widely accepted as the best propagation medium (20), mainly for its good aeration and aseptic conditions, other media promote rooting at least as well as sand: vermiculite (13,17), screened cinders (18), peat moss (15,25), peat and perlite (9), and sand mixed equally with either peat (10,15,25) or vermiculite (5). No significant differences in growth and flowering of poinsettia plants were found among twenty soil mixes (3).

The purpose of this study was to determine the effect of several auxin-containing substances during the rooting of poinsettia cuttings and to observe the subsequent growth and flowering response of plants initially treated with these compounds.

Materials and Methods

Vegetative terminal cuttings of poinsettia, *Euphorbia pulcherrima* Willd., cvs. Dark Red Annette Hegg and Mikkel White Rochford, were cut uniformly to 8.75 cm. The basal 2.5 cm of five cuttings was dipped for 15 seconds for liquid treatments or dipped singly in the powder treatments and tapped lightly to remove the excess. Chemicals tested for root promotion were Jiffy Grow (1000 ppm auxins), Chloromone (750 ppm auxin-like substance), Hormodin No. 2 (3000 ppm IBA) and Rootone F (1700 ppm auxins) (Table 1). These compounds were previously found to be the most effective on poinsettia. For each experiment there were two to four replications, each with five cuttings. In the two time

Table 1. Auxin-containing chemicals tested for stimulating rooting of poinsettia cuttings.

Commercial name	Chemical name	Company supplying	Concentration
Chloromone	Indole naphthylacetamine	Chlorophyll Corp. of America	750 ppm
Hormodin	3-indolebutyric acid	Merck	No. 2 powder
Jiffy Grow	2-naphthaleneacetic acid	G and W Products	1000 ppm
	3-indolebutyric acid		
Rootone F	1-naphthalene acetamide	AmChem	powder
	2-methyl-1-naphthalene acetic acid		
	2-methyl-1-naphthalene acetamide		
	3-indolebutyric acid thiram		

interval studies, in August and November, cuttings were stuck in a raised propagation bench filled to a depth of 15 cm with sterilized coarse sand and equipped with overhead intermittent mist system. Thermostatically controlled bottom heat maintained the medium at 21 to 25°C; air temperatures were 21 to 27°C day and night. Photoperiodic lighting was employed nightly in the second study from 10 PM to 2 AM. Groups of cuttings were harvested at 14, 16, 18 and 20 days after sticking, and data on number of roots, fresh and dry root weights were taken.

To study subsequent growth and flowering as influenced by root promoters, the cuttings were stuck October 8, 2.5 cm deep in 5 x 5 cm square plastic pots filled with 1:1:1 (soil, peat, perlite) soil mix. Bottom heat was maintained as before, and after 20 days, rooting data was taken on two replications, and the remaining four replications were planted in the same soil mix, three cuttings of one treatment and cultivar in a 15 cm clay pot. Plant height, number of mature and immature leaves were recorded at potting. Data on plant height, bract diameter, and plant quality were measured December 18. The results were analyzed statistically, with analysis of variance obtained for each rooting variable and mean separation done by Tukey's H.S.D.

Results

The results of the first study are shown in Table 2. These data were not analyzed statistically due to the loss

Table 2. The effect of chemical promoters on the rooting response of poinsettia cuttings harvested 14, 16, 18 and 20 days after sticking. Study was conducted from August 12 to September 1.

Treatment	Concn.	14 Days No. roots	14 Days Fresh wt.(g)	14 Days Dry wt.(g)	14 Days Fresh wt. per rt.	16 Days No. roots	16 Days Fresh wt.(g)	16 Days Dry wt.(g)	16 Days Fresh wt. per rt.
Jiffy Grow	1000	18.8	0.128	0.028	0.0068	42.2	0.741	0.088	0.0176
Jiffy Grow & Hormodin	1000 No.2	19.4	.116	.026	.0060	54.0	.681	.116	.0126
Hormodin	No.2	16.4	.092	.018	.0056	36.4	.461	.081	.0127
Chloromone	750	14.6	.125	.025	.0086	35.7	.679	.086	.0190
Rootone F		17.9	.243	.047	.0136	33.6	.704	.073	.0210
Check		2.0	.005	.001	.0025	14.8	.152	.020	.0103
		18 Days				**20 Days**			
Jiffy Grow	1000	42.1	0.832	0.095	0.0198	52.2	1.069	0.122	0.0205
Jiffy Grow & Hormodin	1000 No.2	54.4	.708	.118	.0130	76.6	1.073	.186	.0140
Hormodin	No.2	58.6	.962	.123	.0164	71.4	1.346	.154	.0189
Chloromone	750	37.0	.858	.098	.0232	39.5	1.042	.118	.0264
Rootone F		35.7	.833	.081	.0233	41.2	1.293	.120	.0314
Check		19.4	.343	.042	.0177	21.2	0.453	.052	.0214

of some cuttings to heat injury caused by a malfunctioning heating cable. The number of roots, fresh and dry root weights were recorded at 14, 16, 18, and 20 days after the cuttings were stuck. All of the chemicals stimulated rooting when compared to those untreated. A fifteen second dip in an aqueous solution of Jiffy Grow at 1000 ppm followed by a dip into Hormodin No. 2 powder resulted in the greatest number of roots throughout the experiment. Jiffy Grow and Hormodin separately produced almost the same number of roots. Chloromone at 750 ppm and Rootone F increased root number to a lesser degree. Fresh and dry root weights were increased over the control cuttings to a similar degree among chemical treatments, with Hormodin No. 2 producing the greatest fresh root weight at 20 days. These treatments also resulted in higher fresh weight per root than the control, except at the end of the experiment. Rootone F produced the greatest fresh weight per root at the four sampling dates.

The cuttings were also observed at 10 and 12 days after sticking. At 10 days, those cuttings treated with the auxin-containing compounds had formed a larger callus tissue than the untreated cuttings. Hormodin No. 2 and in combination with Jiffy Grow caused callus formation along the basal 2.5 cm of the cutting. After 12 days in the propagating bench, all cuttings but the control were rooting or root initials were visible. Root length varied between .5 and 2.5 cm with Rootone F producing the longest roots. Untreated cuttings were callused but no roots had formed.

The second experiment was conducted in November with an additional treatment of Chloromone at 750 ppm followed by Hormodin No. 2 (Table 3 and Figure 1). At 14 days, Jiffy Grow at 1000 ppm followed by Hormodin No. 2 increased root number highly significantly over untreated cuttings. Chloromone at 750 ppm followed by Hormodin No. 2 produced a significant increase in root number. No significant differences among treatments were found in root number or root weights.

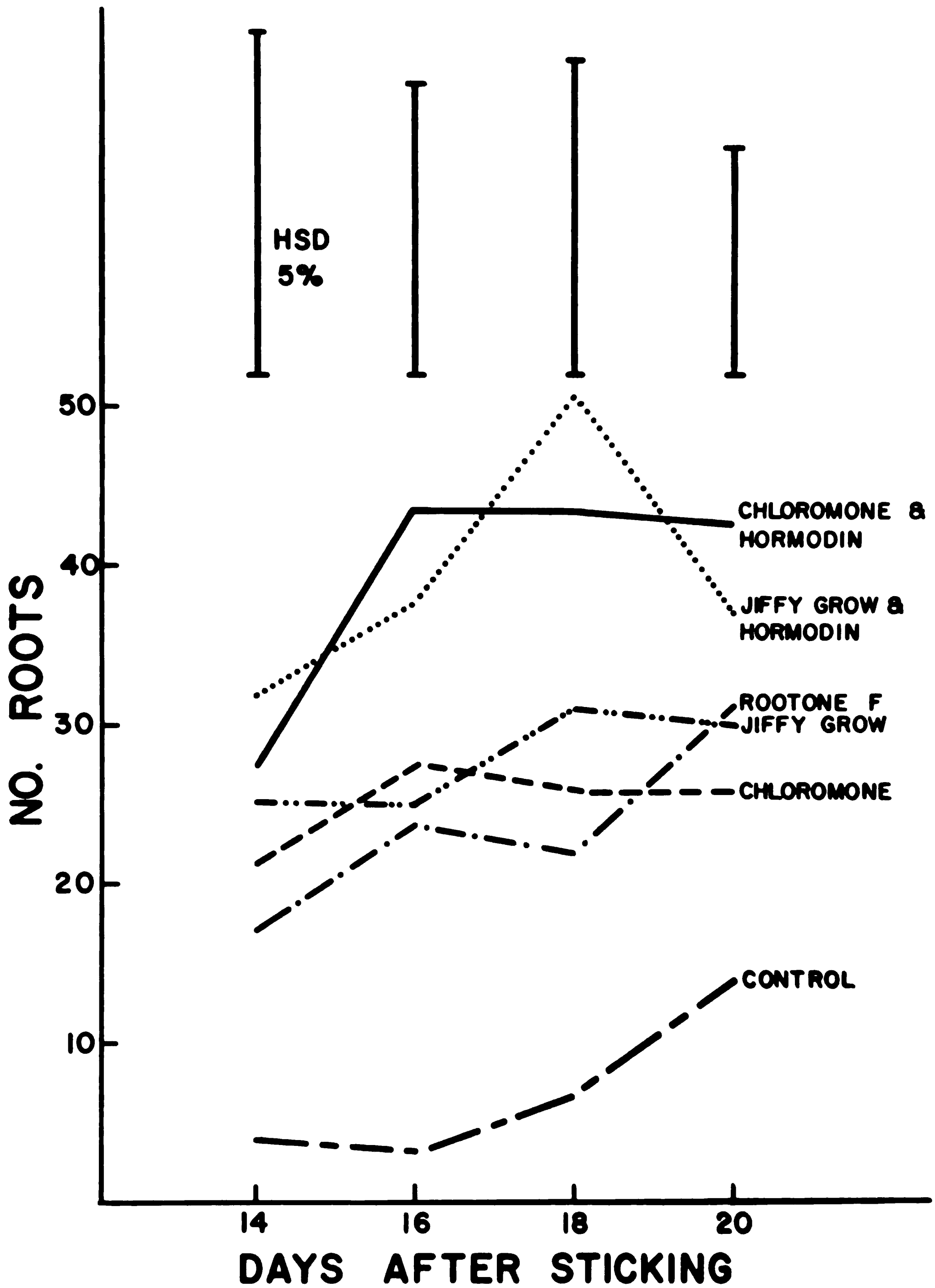
After 16 days in the bench, all cuttings treated with a root-inducing chemical produced significantly greater root number, root fresh weight and fresh weight per root. Root dry weight was significantly increased by all treatments except Chloromone and Rootone F. Jiffy Grow and Hormodin No. 2 in combination produced significantly greater fresh and dry root weights than all other treatments except the combination of Chloromone and Hormodin. Chloromone and Hormodin together did not differ significantly from Chloromone treatment alone.

At 18 days, Jiffy Grow followed by Hormodin No. 2 increased root number significantly over all treatments but Chloromone followed by Hormodin. All chemicals but Rootone F caused significant increases in root number over the untreated cuttings. Increases in root fresh and dry

Table 3. The effect of chemical promoters on the rooting of poinsettia cuttings harvested 14, 16, 18, and 20 days after sticking. Study was conducted from November 2 to November 22.

Treatment	Concn.	14 Days No. roots	14 Days Fresh wt.(g)	14 Days Dry wt.(g)	14 Days Fresh wt. per rt.	16 Days No. roots	16 Days Fresh wt.(g)	16 Days Dry wt.(g)	16 Days Fresh wt. per rt.
Jiffy Grow	1000	25.0	0.334	0.085	0.0122	25.2	0.432	0.086	0.0168
Jiffy Grow & Hormodin	1000 No.2	32.8	.330	.094	.0101	38.1	.784	.153	.0187
Chloromone	750	21.3	.333	.061	.0120	27.0	.468	.063	.0167
Chloromone & Hormodin	750 No.2	26.9	.244	.057	.0082	43.8	.630	.111	.0147
Rootone F		17.1	.200	.044	.0094	24.1	.383	.064	.0150
Check		4.6	.032	.008	.0042	4.0	.054	.013	.0050
H.S.D. (5%)		21.9	N.S.	N.S.	N.S.	18.8	.261	.063	.0096
(1%)		28.1	N.S.	N.S.	N.S.	24.1	.339	.081	.0125
		18 Days				20 Days			
Jiffy Grow	1000	30.9	0.592	0.121	0.0191	29.9	0.604	0.085	0.0223
Jiffy Grow & Hormodin	1000 No.2	50.4	.852	.180	.0180	37.6	.838	.128	.0237
Chloromone	750	26.2	.529	.125	.0188	25.8	.651	.103	.0258
Chloromone & Hormodin	750 No.2	43.8	.860	.190	.0180	41.2	.835	.115	.0208
Rootone F		23.0	.518	.099	.0212	31.1	.626	.067	.0210
Check		6.9	.113	.028	.0160	14.2	.468	.081	.0344
H.S.D. (5%)		19.2	N.S.	N.S.	N.S.	14.4	N.S.	N.S.	N.S.
(1%)		25.0	N.S.	N.S.	N.S.	18.6	N.S.	N.S.	N.S.

Figure 1. Mean number of roots on poinsettia cuttings at 4 sampling dates in response to auxin treatments.


HSD
5%
50
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NO. ROOTS
CHLOROMONE &
HORMODIN
JIFFY GROW &
HORMODIN
ROOTONE F
JIFFY GROW
CHLOROMONE
CONTROL
14
16
18
20
DAYS AFTER STICKING

weights and fresh weight per root were not statistically different from the control at the 5% level.

While Chloromone with Hormodin produced a significantly greater root number than Chloromone alone at 20 days after sticking, Jiffy Grow with Hormodin did not differ in root number from Jiffy Grow alone. All treatments but Chloromone alone significantly increased root number over the control (Figure 2). Increases in root fresh and dry weights were not significant at the 5% level, and no significant differences were found in fresh weight per root.

The subsequent growth and flowering of plants propagated with various auxins was studied. Cuttings were stuck in a soil mix of 1:1:1 soil, peat, perlite, and at the end of 20 days, a portion was harvested (Table 4), and the remainder planted 3 each in a 15 cm clay pot. All treatments except Hormodin No. 2 significantly increased the root number over control cuttings, with the two combination treatments and Rootone F producing highly significant increases. Jiffy Grow and Hormodin in combination produced significantly greater root number than either chemical separately. Chloromone with Hormodin significantly exceeded the root numbers produced by the two chemicals separately. The combination treatments did not significantly increase root fresh and dry weights over the chemicals used separately. The only significant difference in fresh root weight among chemicals was that of Rootone F over Hormodin No. 2. Dry root weight was not significantly

Figure 2. The rooting response of cuttings of Dark Red Annette Hegg at 20 days to (left to right) Jiffy Grow 1000 ppm, Hormodin No. 2, Jiffy Grow 1000 ppm and Hormodin No. 2, Chloromone 750 ppm, Rootone F and untreated. Study was conducted from August 12 to September 1.

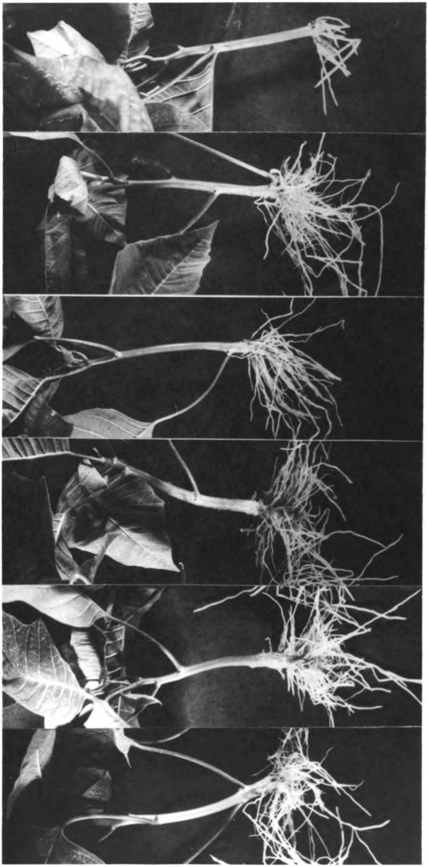

Table 4. The effect of auxin-containing substances on root promotion of poinsettia cuttings in soil mix. The study was conducted from September 8 to September 28.

Treatment	Concn.	Mean root no.	Mean fresh root wt.(g)	Mean dry root wt.(g)	Mean fresh wt. per root
Jiffy Grow	1000	53.4	1.105	0.084	0.0210
Jiffy Grow & Hormodin	1000 No.2	81.2	0.916	0.070	.0113
Hormodin	No.2	52.2	0.688	.058	.0136
Chloromone	750	53.5	1.013	.076	.0194
Chloromone & Hormodin	750 No.2	92.6	1.007	.089	.0126
Rootone F		66.0	1.355	.096	.0201
Check		25.8	0.435	.036	.0153
H.S.D. (5%)		26.6	0.508	.042	.0092
(1%)		33.8	0.644	.054	N.S.

different among treatments. The only significant difference in fresh weight per root was found with Jiffy Grow over the combination of Jiffy Grow and Hormodin.

On the date that the remaining cuttings were potted, the height and number of mature and immature leaves were recorded (Table 5). Plant height of cuttings treated with Rootone F was significantly greater than untreated cuttings. No significant difference was found among chemicals tested. Jiffy Grow at 1000 ppm and Chloromone at 750 ppm in separate application produced a significantly greater number of mature leaves at potting than the two chemicals used in combination with Hormodin or Hormodin alone. No significant differences in number of immature leaves were found. Plant height was recorded also on November 9 (Table 5). Plants propagated with all the root-inducing substances except Rootone F and Chloromone were significantly taller than the control plants, with Hormodin No. 2 resulting in highly significantly taller plants. There was no difference in plant height among treatments.

Plant height of auxin-treated cuttings at flowering (Table 5) was significantly taller than control plants at the 1% level with Hormodin No. 2, and at the 5% level with Jiffy Grow and Chloromone plus Hormodin. Final height was not different among the chemicals tested. No significant increases in bract diameter were found. Days to flower (number of days from initiation of short days, October 4, to anthesis) was reduced by Hormodin No. 2 and Chloromone

Table 5. The effect of auxin-containing substances employed during propagation on the subsequent growth and flowering of poinsettia.

Treatment	Concn.	Ht(cm) 9/28	No.mat. lvs. 9/28	No.immat. lvs. 9/28	Ht(cm) 11/9	Ht(cm) 12/18	Br.diam. 12/18	Days to flower	Rating
Jiffy Grow	1000	9.0	6.1	3.5	13.4	15.8	20.2	76.7	2.0
Jiffy Grow & Hormodin	1000 No.2	7.5	5.2	3.2	13.1	15.2	22.0	76.1	2.3
Hormodin	No.2	8.8	5.3	3.4	13.9	16.4	22.6	73.4	2.5
Chloromone	750	8.7	6.2	3.4	10.9	13.6	19.4	77.3	1.8
Chloromone & Hormodin	750 No.2	8.0	5.4	3.2	13.4	15.9	24.2	72.7	2.3
Rootone F		9.3	6.4	3.2	12.4	14.4	20.9	77.0	2.2
Check		7.3	5.2	3.4	9.8	11.8	20.1	82.6	1.5
H.S.D. (5%)		1.8	0.8	N.S.	3.2	3.6	N.S.	5.8	N.S.
(1%)		2.2	1.0	N.S.	3.9	4.3	N.S.	7.0	N.S.

plus Hormodin at the 1% level, and by Jiffy Grow and Jiffy Grow plus Hormodin at the 5% level. Days to flower were not different among treatments. The plants at flowering were not significantly different in quality rating as related to treatment (1 = poor, 2 = average, 3 = excellent).

Discussion

Chadwick and Kiplinger (6) reported that Rootone and 3-indolebutyric acid at 1, 3 and 5 mg per 100 cc increased the rooting percentage of poinsettia cuttings over the time they remained in the propagating bench. They concluded that the time required to reach normal rooting was decreased by using these auxins. Our results of the data taken at time intervals of 14, 16, 18 and 20 days show that in the summer, Jiffy Grow (NAA and IBA) at 1000 ppm, Hormodin No. 2 (0.3% IBA), and these two chemicals in combination produced cuttings which rooted to a greater degree after 16 days in the bench than the untreated ones after 20 days. Chloromone at 750 ppm and Rootone F also speeded rooting. At 20 days, cuttings treated with these auxins had greater root number and root fresh and dry weights than untreated cuttings. In the winter, the root-inducing chemicals produced cuttings at 14 days which rooted as well or better than untreated cuttings after 20 days in the propagating bench. A combination treatment of Jiffy Grow at 1000 ppm followed by Hormodin No. 2 resulted in consistently significant increases in root number at the 1% level.

All treatments except Hormodin No. 2 significantly increased root number over untreated cuttings in soil mix. The two combination treatments produced root numbers greater than all other treatments. Root fresh weight was greatest after treatment with Jiffy Grow and Rootone F.

In comparing the results of the first time interval study conducted in the summer with the winter study, the rooting values were greater in the summer at 18 and 20 days after sticking. At 14 and 16 days, the seasonal factor did not affect root promotion. In the summer, there was not a great benefit by using a combination treatment of Jiffy Grow and Hormodin in comparison to the two chemicals used separately. All chemicals stimulated rooting similarly after 14 and 16 days. At 18 and 20 days, Hormodin No. 2 and Jiffy Grow plus Hormodin produced much greater root numbers than the other treatments. Fresh root weight was not appreciably different among treatments. In contrast, the addition of Hormodin No. 2 to treatments of Jiffy Grow or Chloromone benefited root production in the winter.

The use of these root-inducing chemicals in the propagation of poinsettia results in benefits in subsequent growth and flowering. Significant height increases at flowering were observed with treatments of Jiffy Grow, Hormodin No. 2, and Chloromone plus Hormodin. Increases in bract diameter were nonsignificant. All treatments but Rootone F and Chloromone significantly reduced the number of days to flower, by as great as 9 days. The addition of

Hormodin to chemical treatments of Jiffy Grow or Chloromone did not significantly improve subsequent growth and flowering over separate application of these two chemicals.

Root production in soil mix was greatly enhanced by use of these auxins. All chemicals tested significantly increased root number over the control. The addition of Hormodin to treatments of Jiffy Grow or Chloromone significantly increased root number over the two chemicals in separate application.

These auxin-containing substances have been shown in previous experiments to increase rooting of poinsettia cuttings. The results presented here demonstrate that the time necessary to root cuttings is reduced with application of these chemicals at sticking and that they perform as well in soil mix as in a sand medium. The final height of plants treated at propagation with several of these chemicals can be increased over that of the control plants and the time to flower can be reduced by 5 to 9 days.

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