to sticking we cut the top and strip the lower end, that's all. Using this method, one man can make, dip and stick 3300 cuttings in 7 hours.

In all instances the Captan gave better rooting than did Rootone. The root system with Captan was heavier, longer and usually whiter. The benches are open and a temperature of 60°F is kept in the greenhouse during rooting. (Slides were shown to illustrate the differences in the rooting.)

We buy 4 lbs of Captan for $2.95; Rootone costs about $8.00/lb. We feel there is a considerable saving in this.

MODERATOR GRAY: Thank you for that fine presentation. The next speaker is a young fellow who has worked at the University of Rhode Island on a study of the rooting cofactors in some of the easy and difficult-to-root clones of rhododendrons. This work was done as his Master of Science research problem under the direction of Dr. John McGuire. He is now at Cornell University working on his Ph.D. It gives me a great deal of pleasure to introduce to you Mr. Choong Lee who will present his paper to you.

THE RELATIONSHIP BETWEEN ROOTING COFACTORS OF EASY AND DIFFICULT-TO-ROOT CUTTINGS OF THREE CLONES OF RHODODENDRON[1]

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Extremely poor rooting of cuttings of some clones of *Rhododendron* is one of the factors which decreases the production efficiency of rhododendron. Some endogenous rooting factors, other than auxin, which control rooting are believed to occur in easy-to-root cuttings of some genera, but to be present in a smaller amount or absent in the difficult-to-root ones (1,3,4,5,6). Hess (2) suggested that the presence of four root-promoting substances, named rooting cofactors, in extracts from stem tissues of the juvenile form of *Hedera helix* L. cuttings was responsible for its high rooting capacity. The rooting cofactors have also been found in other plants and were related to rooting ability (2,4,6). They have not previously been studied in *Rhododendron.*

Objective of this study was to determine the relationship between rooting cofactor or inhibitor level and the clonal and seasonal variation in rooting response of cuttings in three clones of rhododendron.

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[1]This work was carried out under the auspices of Dr. John J. McGuire, Department of Horticulture, University of Rhode Island. The material is a portion of a thesis submitted by the author to the Graduate School of the University of Rhode Island in partial fulfillment of the requirements for the Master of Science degree.

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MATERIALS AND METHODS

Experiment I

An easy-to-root clone of *Rhododendron,* 'Cunningham's White', an intermediate-to-root clone, 'English Roseum', and difficult-to-root clone, 'Dr. H. C. Dresselhuys', grown under natural conditions were used in the study. Terminal stem cuttings with leaves were taken on July 10, September 15, and November 15, 1967. The stem and leaf tissue of the cuttings were frozen, lyophilized, and ground separately. One gram samples of ground tissue were extracted with anhydrous methanol at 0°C. The extracts were dried *in vacuo* at 35±2°C and the residue was taken up in 4 ml of methanol. Re-dissolved extract of 0.25 ml was applied to a 5 cm wide strip of Whatmann No. 3 MM chromatographic paper. After streaking, the papers were immersed in a solvent system of isopropanol:water (8:2 v/v) for development at 2°C for reducing chlorophyll streaking. When the solvent front had ascended for 30 cm, the chromatograms were removed and dried in a hood for 2 hours. The chromatograms were cut into 15, 2-cm sections and a control section was cut from the paper above the solvent front. They were bioassayed to determine their root-promoting or inhibiting activity by the mung bean rooting test developed by Hess (3, 4).

Average number of roots initiated in the check vial and those at the regions of R_f 0.07-0.13, 0.27-0.33, 0.60-0.67, and 0.80-0.87, as reported by Hess (2) to be rooting cofactors 1, 2, 3, and 4, respectively, and also at the inhibitory region of R_f 0.00-0.07 were compared and the amount of each cofactor or inhibitor was determined. The mung bean bioassay was repeated three times at each of the three seasons.

Experiment II

Reciprocal side grafts were made to determine the effects of transmittable endogenous substances from scion to rootstock on rooting response of the cuttings in the three rhododendron clones.

Terminal 4-inch stem cuttings were taken on September 13, 1967. The lowest inch of stem and flower buds, if present, were removed. Each cutting contained five leaves. One-third to one-half of each leaf was removed depending on the leaf size. One of the leaves on the stem was replaced by a leaf and bud scion of another clone using the side graft method. The leaf of the scion was not shortened. All possible combinations of grafts among the three clones of *Rhododendron* 'Cunningham's White', 'English Roseum', and 'Dr. H. C. Dresselhuy's were made. Cuttings in each clone, without grafting, were used as controls.

All cuttings were wounded slightly and were dipped for 10 seconds in an auxin solution of 0.1% IBA, 0.1% NAA, and 50 ppm boron in ethanol. Cuttings were then planted in a randomized block design in a medium of sphagnum peat moss and perlite (1:1 v/v). Within a month the graft unions were healed. After three months the percentage of cuttings rooted and the diameter of the root ball on the cuttings were recorded.

RESULTS AND DISCUSSION

Experiment I

The root-promoting activity of extracts from stem and leaf tissues of the three rhododendron clones as indicated by number of roots initiated on mung bean cuttings, is shown in Figure 1, 2, and 3. The horizontal line in the histograms represents the average number of roots per cutting on the control. Columns above the horizontal line and below the horizontal line represent promotion and inhibition, respectively, of root initiation in comparison to controls.

(A) July experiment (Fig. 1). Extracts from stem tissue of 'Cunningham's White' contained four rooting cofactors located at the regions of R_f 0.1, 0.3, 0.63, and 0.83, respectively. Two rooting cofactors, 2 and 4, were found in extracts from stem tissue of 'English Roseum', and only cofactor 4 was found in stem tissue of 'Dr. H. C. Dresselhuys'. A rooting inhibitor was found in significant quantities at the region of R_f 0.03 in stem extracts of 'Cunningham's White' and 'English Roseum'. 'Dr. H. C. Dresselhuys' had the inhibitor present but not in a significant amount.

Leaf tissue of 'Cunningham's White' contained two cofactors, 2 and 4, and leaf tissue of 'English Roseum' had three

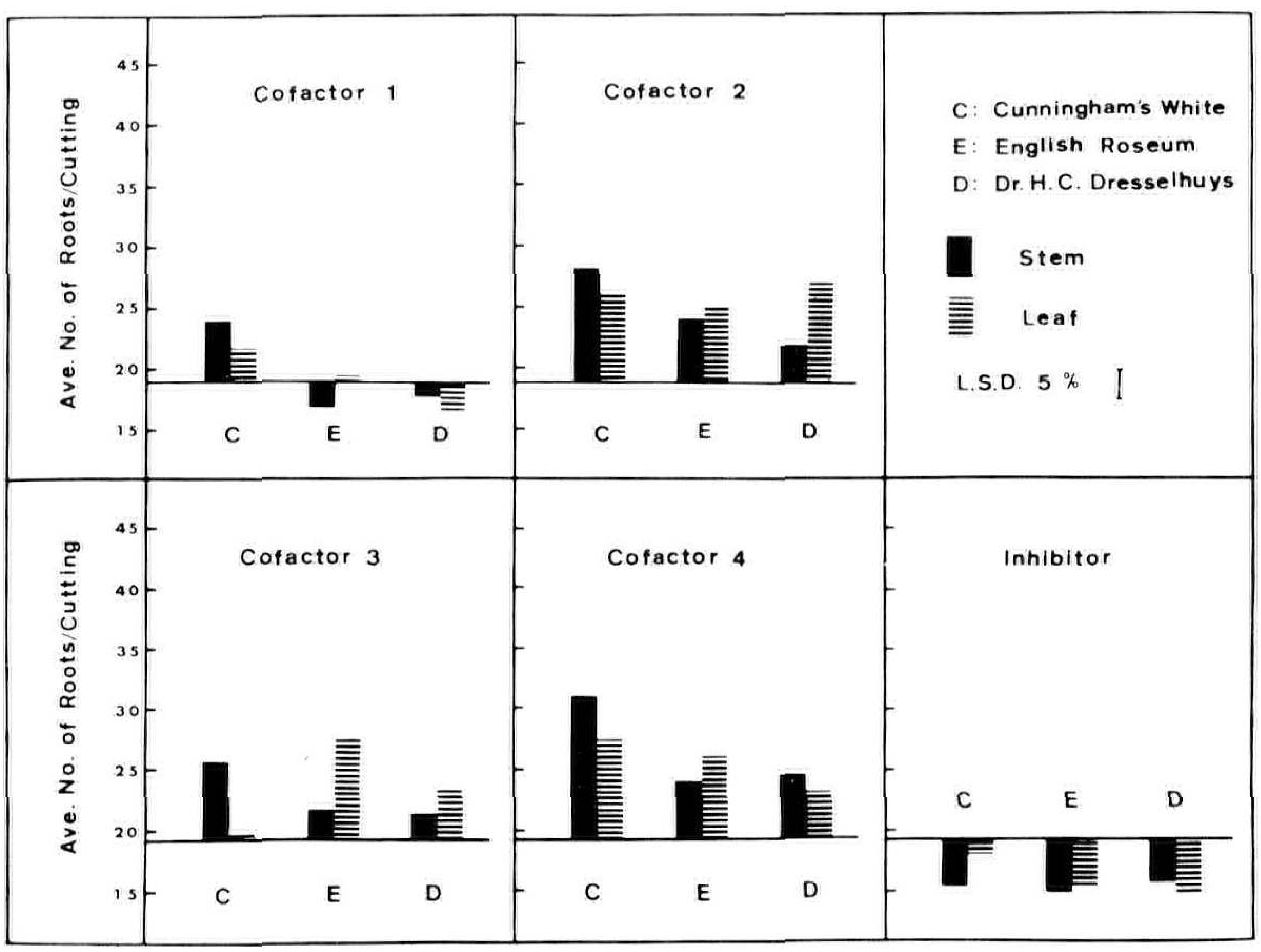

Fig. 1. Number of roots initiated per mung bean cutting treated with rooting cofactors and inhibitor extracted from rhododendron shoots collected on July 10, 1967.

cofactors, 2, 3, and 4. Only cofactor 2 was present in leaf tissue of 'Dr. H. C. Dresselhuys'. No significant inhibiting effect was found in extracts from leaf tissue of 'Cunninghham's White' or 'English Roseum', but 'Dr. H. C. Dresselhuys' contained an inhibitor.

(*B*) *September experiment* (*Fig. 2*). A considerable increase in rooting cofactor levels, and a decrease in inhibiting activity, as measured by root initiation, was found in each clone, as compared to the July extracts. Extracts from stems of 'Cunningham's White' and 'English Roseum' contained four cofactors with no significant amount of inhibitor. Extract from 'Dr. H. C. Dresselhuys' stems had two rooting cofactors, 2 and 4, with no inhibiting activity. Extracts from leaf tissues exhibited similar trends in amounts of rooting cofactors and inhibitor with those in the extracts from stem tissues.

(*C*) *November experiment* (*Fig. 3*) The decrease of rooting cofactor level and reappearance of the inhibitor in November extracts was remarkable. 'Cunningham's White' and 'English Roseum' stems still contained all four cofactors with no inhibitor, but 'Dr. H. C. Dresselhuys' stem tissue had only cofactor 4 and the inhibitor in significant amounts.

Leaf tissue of 'Cunningham's White' and 'English Roseum' had all four rooting cofactors, whereas 'Dr. H. C. Dresselhuys' contained only two confactors, 2 and 4. The inhibitor was not found in significant amounts in the leaf tissue of any clone.

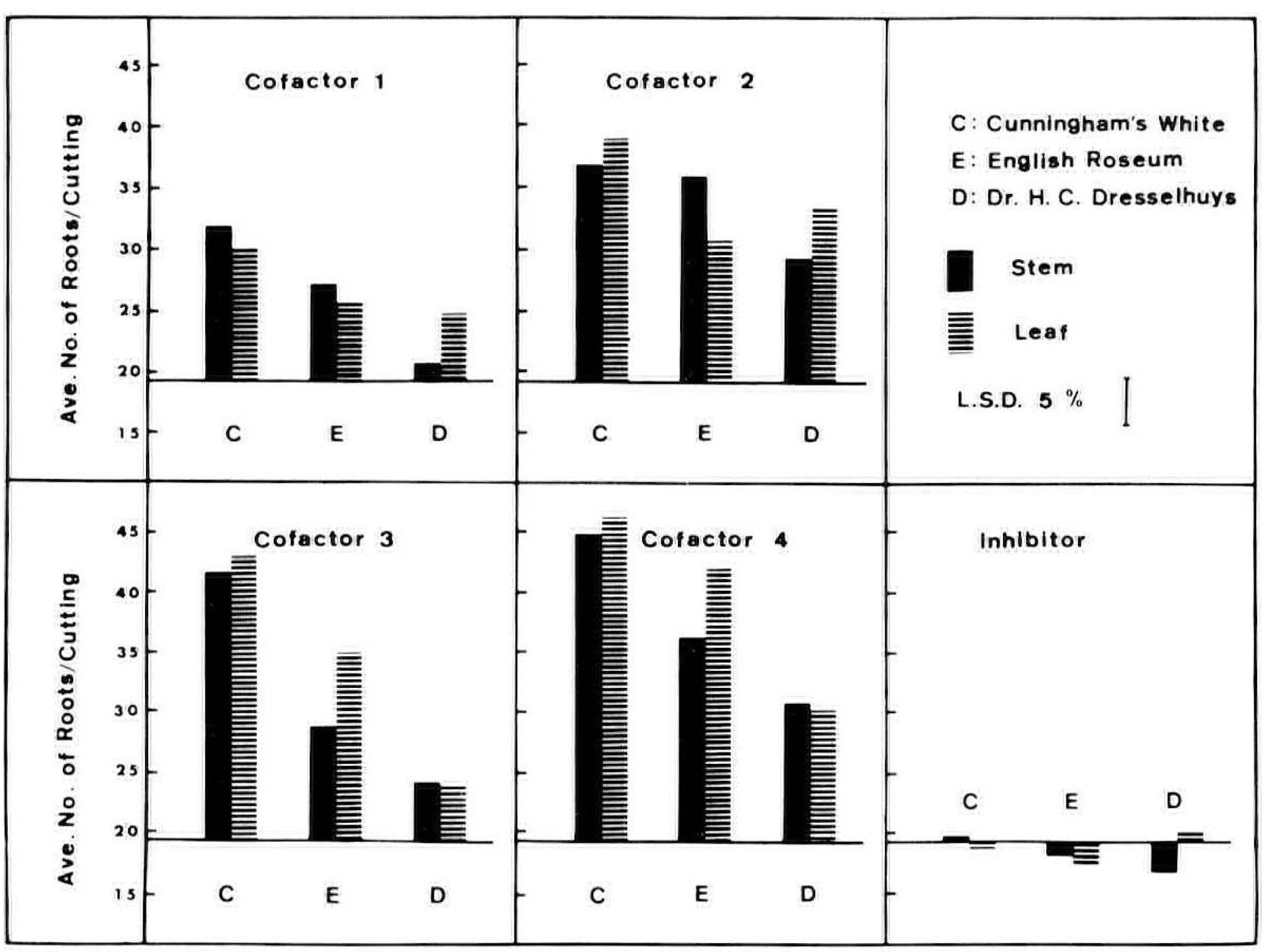

Fig. 2. Number of roots initiated per mung bean cutting treated with rooting cofactors and inhibitor extracted from rhododendron shoots collected on September 15, 1967.

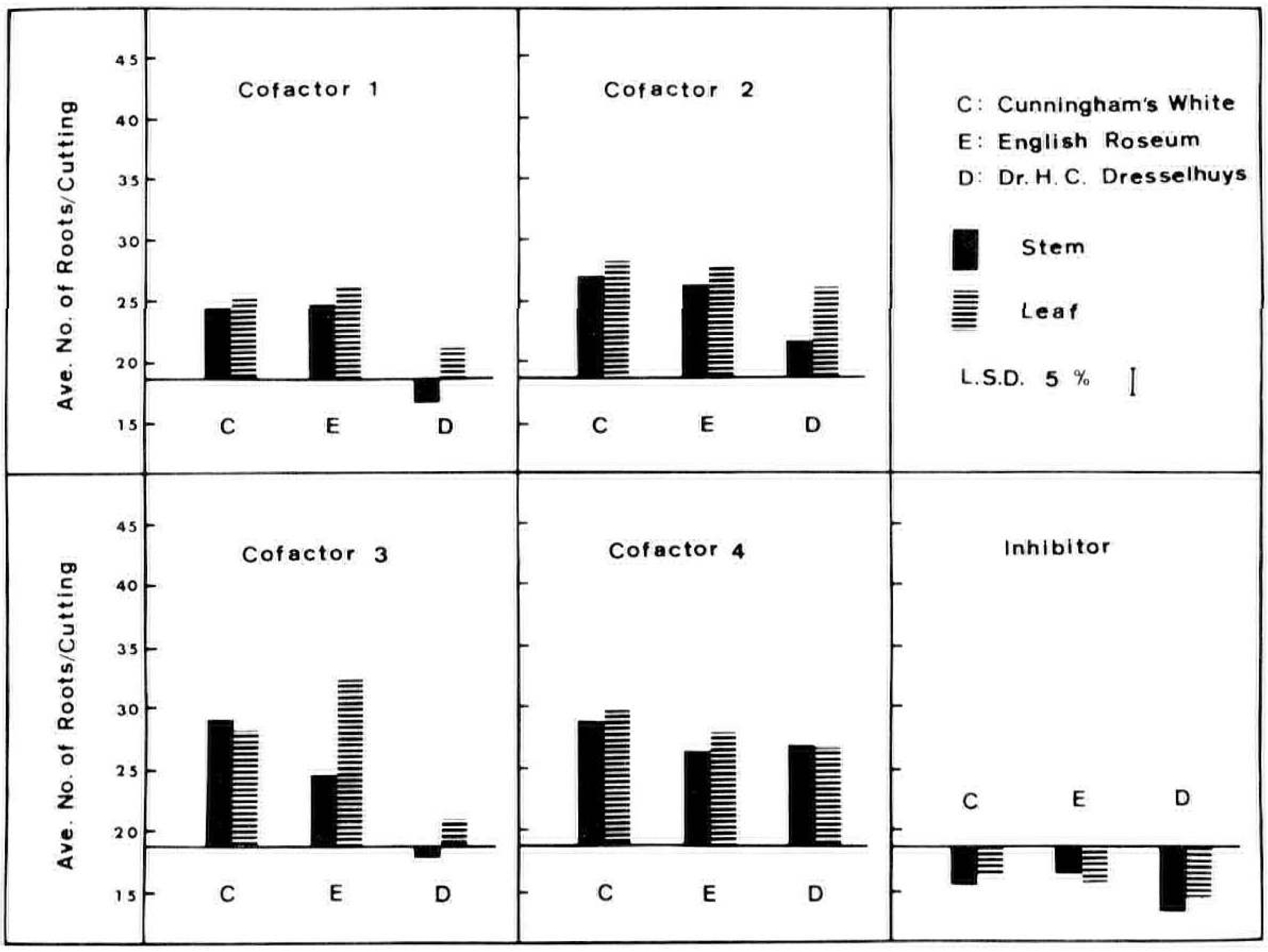

Fig. 3. Number of roots initiated per mung bean cutting treated with rooting cofactors and inhibitor extracted from rhododendron shoots collected on November 15, 1967.

These results generally showed that in every season the levels of endogenous rooting cofactors were greatest in 'Cuningham's White', followed in order by 'English Roseum' and 'Dr. H. C. Dresselhuys'. 'Cunningham's White' roots very easily with 100% rooting, 'English Roseum' shows intermediate rooting response of 71% rooting, and 'Dr. H. C. Dresselhuys' has 29% rooting (Table 1). These rooting percentages are similar to the number of rooting cofactors and it seems likely that differences between clones of rhododendron in rooting response may be related to the level of rooting cofactors contained in the cuttings. Other investigators (1, 3, 6) have previously reported a relationship between rooting ease and amount of endogenous root-promoting substances.

The effect of substances inhibitory to root initiation has been studied in many plants (1, 3, 6). In these experiments, more of the inhibitor was found in the July extracts from stem tissues of 'Cunningham's White' and 'English Roseum' than 'Dr. H. C. Dresselhuys'. In September extracts neither stem nor leaf tissues of any clone contained inhibitor, in spite of definite differences between clones in rooting response (Table 1). These facts indicate that rooting cofactors may be more responsible for the rooting ability of rhododendron cuttings than is the inhibitor.

Rooting cofactor levels contained in the stem tissue of 'Cunningham's White' were not less than those in the leaf tissue. In contrast, cofactor levels present in the stem tissue of 'English Roseum' and 'Dr. H. C. Dresselhuys' were less than those in the leaf tissues. These indicate that rooting cofactors contained in poorer rooting clones may be less translocatable and this characteristic may be one of the reasons causing difficulty in rooting of the cuttings.

Root inducing activities and amount of rooting cofactors were increased considerably in September and decreased again in November to the level of July extracts. Conversely, the inhibitor found in the July extracts disappeared in the September and reappeared in November extracts. These results may be associated with the fact that better rooting response can be obtained in late summer or fall than in any other season.

Experiment II

Table 1 shows the effect of different scions on size of root ball and the percent of cuttings rooted for three *Rhododendron* clones. A leaf and bud scion of 'Cunningham's White' significantly improved both rooting percentages and root ball size of cuttings of 'Dr. H. C. Dresselhuys'. Similar scions did not significantly increase rooting of the intermediate-to-root 'English Roseum' cuttings, but the tendency for increased rooting capacity could be found.

The rooting capacity of 'Cunningham's White' or Dr. H. C. Dresselhuy's was not appreciably affected by a leaf and bud scion of 'English Roseum'.

Scions of 'Dr. H. C. Dresselhuys' reduced rooting response of 'Cunningham's White' cuttings. The scion did not influence the rooting capacity of 'English Roseum' cuttings. Other investigators (6, 7) have found that rooting of some difficult-to-root cuttings could be increased by grafting onto the cutting a leaf and bud scion from an easy-to-root cultivar.

Table 1. Effect of different scions on size of root ball and percent of cuttings rooted for three *Rhododendron* clones.

Group	Stock[1]	Scion[1]	Diameter of root ball (inches)	Percent rooted
I	C	none	2.88	100
	C	E	1.95	92
	C	D	1.56	88
II	E	none	1.36	71
	E	C	1.68	92
	E	D	1.39	84
III	D	none	0.22	29
	D	C	1.36	96
	D	E	0.87	51

[1]C = **Rhododendron** 'Cunningham's White'
E = **Rhododendron** 'English Roseum'
D = **Rhododendron** 'Dr. H C Dresselhuys'
L.S D. at 5% level for root ball diameter: Group I = 0 96, Group II = N.S., Group III = 0.86.
L.S.D. at 5% level for % rooted Group I = 7.60, Group II = N.S., Group III = 42.00.

Results in this experiment indicate the presence of transmittable endogenous root-promoting substances in scions and it shows a clonal variation in amount of these substances. It seems likely that improving rooting capacity of 'Dr. H. C. Dresselhuys' may be due primarily to the increase of total endogenous root-inducing substances translocated from the scion of 'Cunningham's White', which was a rich source of the promotive substances. On the other hand, reducing rooting response of 'Cunningham's White' cuttings with the scion of 'Dr. H. C. Dresselhuys' may be attributed to the decreasing content of root-promoting substances rather than inhibitor from the scion which contained the least amounts of rooting cofactors.

SUMMARY

The level of endogenous root-promoting and inhibiting-substances in the three clones of rhododendron were compared at seasonal intervals in order to study the clonal and seasonal variation in rooting response of cuttings. The highest levels of four rooting cofactors in any season were found in both stem and leaf tissue of the easily-rooted clone of *Rhododendron* 'Cunningham's White' and followed by the intermediate-to-root clone of *Rhododendron* 'English Roseum'. The difficult-to-root clone of *Rhododendron* 'Dr. H. C. Dresselhuys' contained the least amount of the rooting cofactors. An inhibitor was often found in all clones, but it appeared less responsible for clonal differences in rooting response than variation in levels of the rooting cofactors. The promoting activity of rooting cofactors in all tissues of the clones increased in September and decreased again in November to the level of July extracts. Inhibitor found in the July extract disappeared in September and reappeared in November.

Rooting response of cuttings of 'Dr. H. C. Dresselhuys' was significantly improved by grafting a leaf and bud scion of 'Cunningham's White'. On the other hand, scions of 'Dr. H. C. Dresselhuys' resulted in decreased rooting of cuttings of 'Cunningham's White'. Rooting capacity of 'English Roseum' was less affected by a scion of other clones of rhododendron.

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MODERATOR GRAY: Congratulations on your presentation, but most of all, on your diligence in this particular study. I feel you will do well in the field of plant propagation. The next speaker on the program really needs no introduction, Mr. Peter Vermeulen.

EDITORS NOTE: International President, Mr. Peter Vermeulen, gave a brief review of the talks presented at the meeting of the Region of Great Britain and Ireland in September, 1969. These talks and the Business Meeting report are printed in their entirety in this volume of the Proceedings and therefore his review of the papers is not presented here.