their inventions were used.

If we look to our brethren in the floriculture industry, we will find that they co-operate very closely indeed with the universities and the U.S.D.A. They recommend where they think research can be of the most use, they maintain close contact when this is being done, and finally they put the results of the work to use. Of course, their prime interest in growing is how many cents they can get per square foot of bench space. Most of us commercial nurserymen are more interested in the beauty of the plants. Now this is no crime and indeed it is an asset. If we are enthusiastic about our product so will be our customers. But we can learn from the floriculturist. We need to follow his example in co-operating with academic research and with applying the results it achieves. But to do this we have to experiment ourselves under our production conditions.

If we are successful in this, our industry will not only be more progressive but it will also appear more attractive to the type of employee we need now and will need even more in the future. This is the space age and few aggressive, ambitious young men want to be associated with an anachonism in industry. To progress we have got to:

1. Acquire
2. Translate
3. Apply

the results of academic research.

To achieve this spells out the need for research on the nursery level.

MODERATOR MULLIN: We will proceed with the next speaker who represents one of three major research areas — the university, the U.S.D.A., and private industry. Our speaker is from the second area, the U.S.D.A. Dr. Marc Cathy will discuss what a propagator should do to pace the development of his plants.

PACING DEVELOPMENT OF WOODY PLANTS

HENRY M. CATHEY[1]

Many growers have already made great advances in accelerating handling of woody plants. Most growers still aim their material towards seasonal sales for plants to be used as foundation plantings for the home, business, or factory. Growers must continue to service the landscape horticulturist but they also must service markets with cuttings and liners of woody plants that have been regulated. Regulated liners will provide plants for decoration inside the home and also can be used as plantings outside the home. Many berried or flowering plants are now on the market that can also serve as decorative house plants.

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Through the years, the hydrangea, gardenia, and azalea varieties selected for inside culture have lacked hardiness for garden use. With advances in regulating growth of many woody plants, the propagator again has the opportunity to service a new market area and to produce useful plants in a minimum time. Pacing growth and development of woody plants is possible through procedures already widely practiced by ornamental plant growers.

Regulated culture of woody plants immediately excludes some of the more common practices used by the grower. Trimmings from older plants or cuttings from special blocks of plants growing in the field seldom root and grow uniformly. Most growers take cuttings at a particular time of year and use large cuttings to get flower and fruiting plants the first year of culture. Basic information on ways to regulate the stock plants and cuttings for maximum response and growth control is needed. When the grower learns to make use of the environment, endogenous growth substances, and exogenously-applied growth substances, he then will develop precise growing techniques for servicing the needs of a year-round producing and selling woody plant industry.

Research work on stock plants, cuttings, and procedures to produce the mximum regulation are reported in the *Proceedings* of the Plant Propagators' Society. Identification and reapplication to cuttings of factors and co-factors responsible for rooting will simplify the area of stock plant-cutting production. Regulated growth for continuous cutting production of woody plants should be the aim of any growing procedure.

Part of our research program in the Ornamentals Investigations at Beltsville, Maryland, is concerned with studyig the woody plant liner. Our aim is to provide suitable media, fertilizers, and disease control programs to allow for the regulation and scheduling of production of woody plants — not on a seasonal basis — but on a weekly basis.

Control of Vegetative Growth

Stem Elongation Regulation. Vegetative growth of woody plants is controlled by phytochrome (1) in a dramatically-evident way through extension of short days with low intensity light of various wavelengths, or by interruption of long night periods with a few hours of light of low intensity. The literature concerning photoperiodism in woody plants has been reviewed by Wareing (10), Nitsch (5), and more recently by Romberger (6).

We will consider growth of *Rhododendron* "Roseum elegans", well known hybrid of *R. Catawbiense* Michex., in some detail. Supplemental artificial light during the night promotes vegetative growth of rhododendron. It exhibits many of the control features of herbaceous plants with flowering occurring naturally after 8 or 9 flushes of growth.

Rhododendron plants were grown on 8-hour days with 8-

hour extensions of various types of radiation. The light sources were predominantly far-red (photographic safety light); near equal amounts of red to far-red (incandescent filament light); and predominately red (fluorescent light). The radiant energy from the 3 kinds of lamps was adjusted so that the energy in the red part of the spectrum was the same in all treatments. All 3 light sources promoted stem extension. Incandescent filament lamps gave the maximum elongation of each flush; far-red, second; and red, third.

Waxman reported the usefulness of intermittent light on a range of woody plants in the *Proceedings* of the Plant Propagators' Society. Rather than use continuous light, one can use minimal effective light energy and then allow it to act in darkness until dark reduces its effectiveness. Incandescent light given in cycles of less than 60 minutes for 16 hours delays the onset of short-day dormancy in rhododendron plants (Fig. 1). Light given 10% of a 1-minute or 24 minute cycles was equally effective when the night temperature was maintained at 70° F. At 60° F. night temperature, 1-minute cycles were more effective than 24-minute cycles given for 16 hours; 60-minute cycles cause only moderate delay. The minimal duration of light needed to delay the onset of short-day dormancy is 4 hours of intermittent lighting in the middle of the 16-hour dark period.

Figure 1. Plants of Roseum elegans rhododendron were grown on the natural short days of winter and during the middle of the night incandescent light of 20 ft-c was applied as follows: Left to right, natural days, 4 hrs. from 10 PM to 2 AM, 24 minutes from 11:48 PM to 12:12 AM, and 1 minute every 10 minutes from 10 PM to 2 AM. Treatments continued for 4 months.

The response of plants to intermittent lighting was first studied by Garner and Allard (3) and was developed by Hume (4), Withrow and Withrow (12), and by Waxman (11). The response of plants to repeated stimulation of the phytochrome,, the photo-reversible pigment, is observed in many physiological displays in plants (1). One observes the display in inhibition of short-day dormancy, in promotion of stem elongation of long-day plants, and in the delayed flowering of short-day plants.

Branching Regulation. Continued use of long days causes plants to grow with little development of lateral branches; primarily the plants develop a main stem. The woody plant grower must stop the liner to induce development of lateral branches. One can induce multiple bud break of rhododendron plants by limiting their growth for at least 8 weeks on 8-hour days, exposing the plants to temperatures below 55° F. for 8 weeks, and then returning them to long days (Fig. 2). Stopping the plant by removing the growing point is essential, to build the framework for subsequent development of the plant. Thus, manipulations of daylength and temperature may be too time-con-

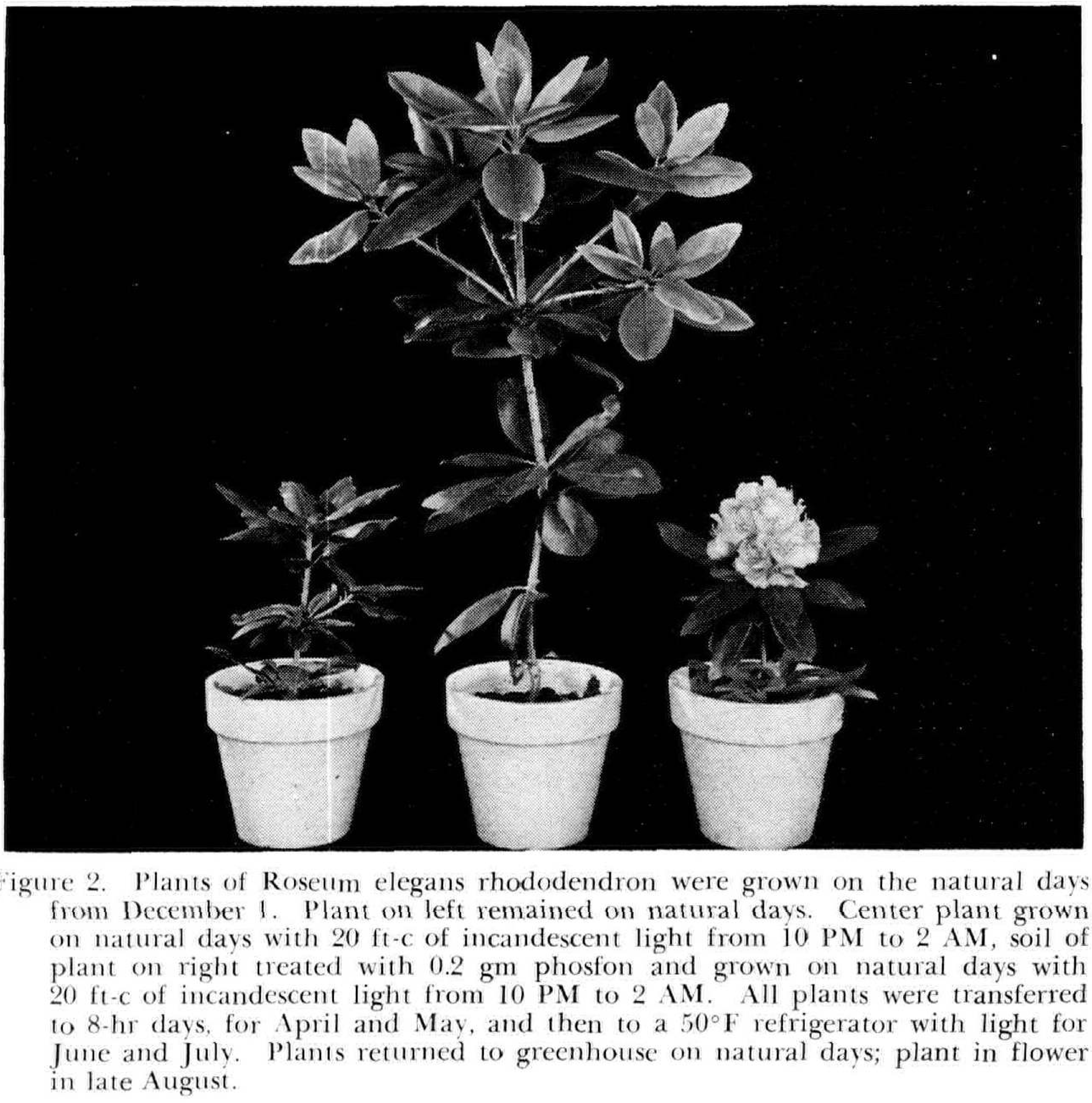

Figure 2. Plants of Roseum elegans rhododendron were grown on the natural days from December 1. Plant on left remained on natural days. Center plant grown on natural days with 20 ft-c of incandescent light from 10 PM to 2 AM, soil of plant on right treated with 0.2 gm phosfon and grown on natural days with 20 ft-c of incandescent light from 10 PM to 2 AM. All plants were transferred to 8-hr days, for April and May, and then to a 50°F refrigerator with light for June and July. Plants returned to greenhouse on natural days; plant in flower in late August.

suming for the grower to use in the accelerated culture of woody plants.

Regulated Growth and Flower Initiation. Regulated flowering is desired in the culture of many woody plants. Many cultural practices are employed to manipulate plant size and flowering time; however, these techniques require that the plants receive constant attention to keep them staked. Also dwarfing understocks often contain viruses which shorten the productive life of the plant.

Stuart (7,8,9) discovered that the growth retardants phosfon, Cysocel, and B-Nine caused suppresion of vegetative growth and prompt initiation of flower buds in rhododendrons. These responses did not depend on minimum age or size of plant. Photoperiod and temperatures modified the dosage response and the persistence of the chemicals. Subsequently, the flowering of Camellia, Ilex, Gardenia, Malus, Pyrus, and Prunus was accelerated in response to applications of growth retardants. Current knowledge in the physiology of the growth retardants was reviewed by Cathey in 1964 (2).

The procedure for regulated flowering of rhododendrons as an example is given below and is illustrated in Figure 2.

Pre-treatment. Select uniform plants. Pinch to promote development of 3 lateral shoots. Treat soil (1 part compost, 2 parts peat, 1 part coarse sand) with non-ionic wetting agent at time of repotting (drench soil with 0.1% solution). Pot plants into 5- or 6-inch clay pots.

Lighting. Grow plants on long days (natural days plus incandescent light 20 ft-c) from 10 P.M. to 2 A.M. Continue lighting for 2 months in summer (June, July, or August) and 4 months in winter (November, December, January, February).

Temperature. Maintain a minimum temperature of 65° F. at all times.

Chemical treatment. When growth is starting, treat lots of plants as follows: 1) Soil drench, phosfon 0.2 g/plant, or (2), spray B-Nine 0.25% 3 times at monthly intervals.

Preparation of Solutions:

Phosfon — 0.2 g/pot. Add 1 oz. 10% Phosfon-D liquid in 15 pints water; treat each pot with 1 pint of diluted chemical.

B-Nine — 0.25% spray. Dilute 5% concentrate, 1 part concentrate to 19 parts water.

Post treatment. Flower buds should appear on treated plants 3 to 4 months after treatment with chemicals. Transfer the plants to natural daylengths to allow flower buds to develop.

Cold storage. Store budded plants at temperatures below 55° F. for a minimum of 8-10 weeks to break the dormancy of the flower buds.

Forcing. Return plants to greenhouse for forcing. A variety will require 4 to 8 weeks to force at 65° F.

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CASE HOOGENDOORN: How much phosphon do you use in the pots?

DR. CATHEY: The rates, on the basis of soil and pot size is in the publications. For example, we grow our plants in one part peat, one part sand, and two parts of composted soil. We treat them with a non-ionic wetting agent which is most important in watering rhododendrons. For a 5 inch pot, for a variety such as America or Nova zembla we would use 0.2 gram to 2.5 gram with the dust on the market, the 10% dust. It would be a little less than one teaspoonful per pot. The rates are fairly high. B-9 is a spray, applied at monthly intervals 3 or 4 times. The temperature has to be high enough and grow them on long days. Nova zembla, from my experience, flowers on the fourth or fifth flush. Roseum elegans flowers on about the 9th flush when grown on long days. When you add growth retardants at any age, about the third flush from the time you started treatment, the plant forms a flower bud. So with B-9 you've got to have it working with each of the flushes. It does not seem to persist so every month you must apply a spray.

CASE HOOGENDOORN: Is it not true that with Phosphon you do not have to apply it every month?

DR. CATHEY: Yes, with phosphon you have to apply it only one time. As long as the rhododendron remains in the pot, it will form one flower bud after another.

CASE HOODGENDOORN: Now if you have a treated phosphon plant in a pot and take it out of the pot and plant it in ordinary soil, how long is that phosphon staying with the plant?

DR. CATHEY: If you put it out in well prepared soil and the root system goes right out into the new soil, it will immediately resume growth and show no effect of the growth retardant. But if the root system is not very vigorous, it will continue to show some of the effects. I would not recommend phosphon in nursery beds because of its persistence. I would think it should only be used for potted plants which would later be planted in beds where the phosphon effect would be diluted. For nursery bed culture, I would think only B-9 should be used. B-9 is much more active and you have to be much more careful about dosage to get the proper response.

CASE HOOGENDOORN: Do you use different dosages for holly and for rhododendron?

DR. CATHEY: No, use about the same rate.

ROBERT DEWILDE: If you were to remove the terminal bud from the rhododendron placed under long days, would this effect side branching without the addition of chemicals?

DR. CATHEY: When we pinch we normally get at the most, in my experience, three or four breaks, and normally two may dominate. This is with Roseum elegans. If you use short days, 8 hour days, for 2 months, and then cold, and then long days, you can get eight or ten breaks from the same size plant. But this process takes 4 months. So pinching and taking the two or three, or at the most four breaks, is apparently the only thing to do.