CONTROLLED RELEASE GROWTH REGULATORS FOR PLANT GROWTH CONTROL AND ROOTING OF CUTTINGS[1]

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Abstract. "Controlled release" chlormequat (2-chloroethyltrimethylammonium chloride) has been demonstrated to effectively modify plant growth This encapsulated growth substance when incorporated into the growing medium, both effectively stimulated earlier flowering in tomatoes and petunias and retarded growth of tomatoes, petunias, snapdragons, marigolds, and other bedding plant species When utilized in a rooting medium, stimulation of early rooting occurred However, subsequent root initiation and development were greatly retarded in geranium cuttings

REVIEW OF LITERATURE

The growth, flowering and rooting of many flower crops, bedding plants and vegetable transplants have been successfully controlled with growth regulators to produce quality horticultural products (2, 3, 12, 13, 14). Growth regulating chemicals applied by various methods have successfully increased the yields of vegetable crops (7, 11), controlled plant size, retarded flower bud initiation, delayed flowering, stimulated earlier bloom, improved transplant quality, increased resistance to cold and other stresses, induced tuberization, improved root systems, and stimulated adventitious root production in cuttings (3, 4, 6, 7, 8, 9). In most cases these responses followed application of the chemicals as foliar sprays, drenches or dips. Often such applications cause a drastic initial reaction in the plant as opposed to a gradual uptake by the roots (7, 8, 10).

Carpenter and Carlson's work (1) along with the work of Read (8) indicated the potential for rooting cuttings with very low levels of chlormequat (Cycocel or 2-chloroethyltrimethylammonium chloride) in the rooting medium. In the latter research, presented at the 1968 I.P.P.S. meetings, we reported the

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effect of SADH (succinic acid 2, 2-dimethyl hydrazide or B-Nine) and chlormequat on rooting of cuttings. In this research SADH stimulated rooting of cuttings while levels of 2000 ppm chlormequat retarded rooting. Both treatments increased tuberous root formation in dahlia; low levels of chlormequat were demonstrated to be stimulative to adventitious root formation in a number of herbaceous species.

In our current research we have emphasized growth control with an encapsulated formulation of chlormequat. A next logical step was to pursue the possibility of improving rooting of cuttings with this material incorporated in the rooting medium.

MATERIAL AND METHODS

Encapsulated chlormequat (3MCAP-CYC)[3] was incorporated into a peat-vermiculite medium for the growth studies and in either peat-vermiculite, or vermiculite alone, for the rooting experiments. Each capsule is composed of an aqueous solution of the active ingredient encased by a polymeric hydrocarbon shell (Fig. 1). The active ingredient is gradually released when the capsule comes in contact with water. Release is effected by

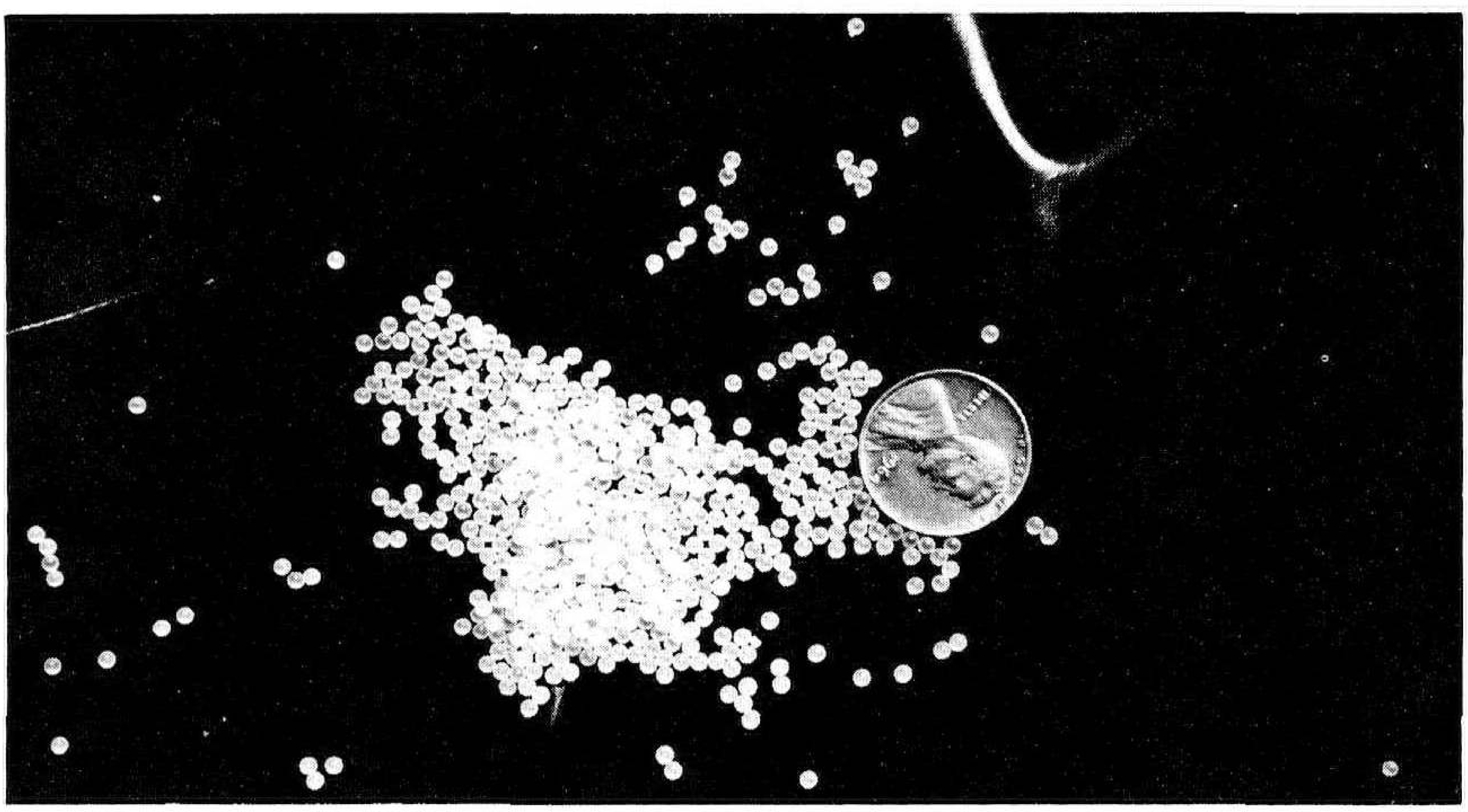

Figure 1. Capsules for encapsulated chlormequat (3MCAP-CYC). Note similarity to commercial controlled-release fertilizers.

[3] Supplied by New Business Ventures Division, 3M Company, St. Paul, Minnesota

equalization of the concentration differential between the capsule solution and the moisture content of the growing medium. The capsules do not physically rupture and the release rate can be controlled by varying the shell composition.

Capsules containing 4% chlormequat were used in these experiments and were mixed thoroughly in a nutrient-enriched peat-vermiculite medium and placed in 10 or 15 cm (4" or 6") polyethylene pots for the growth experiments and in vermiculite-filled flats, or peat and vermiculite-filled Forsyth pots, for rooting experiments. Non-treated plants were maintained as standard controls in all experiments and drenches and/or sprays of chlormequat at 1000 to 4000 ppm were utilized as additional controls for 'Rutgers' tomatoes. Petunia experiments also had the standard application of 2500 ppm SADH (B-Nine) spray. A randomized block design was employed and the experiments were conducted in an 18.5^{0} - 24^{0}C greenhouse (diurnal temperatures) with daily watering and fertilization weekly with 300 ppm N from 20-20-20 fertilizer for the growth studies. Approximately 30 cultivars of petunia and numerous other bedding plant species have been tested. Data and discussion reported here are for 'Red Cascade' and 'Happiness' petunia, 'Rutgers' tomatoes, 'Hot Jazz' salvia, 'Giant Rose Queen' cleome, 'Verns Delight' African violet, and 'Irene' geranium. Tomatoes and cleome were direct seeded, petunias and salvia transplanted at the first true leaf stage, and leaf petiole cuttings of African violet and terminal 4" cuttings of geranium were utilized in these studies. Cuttings of African violet were rooted in home propagating units (Forsyth pots) under cool white florescent lights, while geranium cuttings were rooted under intermittent mist, 15 seconds/7.5 min.

RESULTS AND DISCUSSION

Growth control with 3MCAP-CYC incorporated in the medium was excellent in all experiments with all species. Height control is illustrated in 'Rutgers' tomatoes (Table 1) where 3 to 12.5 grams/liter 4% 3MCAP-CYC incorporated in the medium provided height control similar to drenches or sprays of chlormequat; 25 grams/liter 3MCAP-CYC caused even greater height control, while all 3MCAP-CYC treatments reduced the number of nodes to the first inflorescence, thus providing earlier bloom by up to 2 weeks. Mean stem diameter was sharply increased by 3MCAP-CYC treatments suggesting that the plants are in a better nutritional and carbohydrate status that untreated or drenched controls.

Table 1. Comparison of effects of controlled-release, spray and drench forms of chlormequat on 'Rutgers' tomato plants. [z]

Treatment	Mean height (cm)	No. nodes to 1st inflorescence	Mean stem diam. (mm)[x]
3g 4% 3MCAP-CYC	25.60 c [y]	8.00 bc	8.57 abc
12.5g 4% 3MCAP-CYC	22.74 cd	7.57 c	8.71 ab
25g 4% 3MCAP-CYC	17.94 e	8.14 bc	7.86 a
1000ppm drench	22.79 cd	9.00 ab	7.86 bcde
4000ppm drench	22.92 cd	9.42 a	7.43 cde
2000ppm spray	36.47 b	9.86 a	7.14 de
Control	44.68 a	9.43 a	6.86 e

z/ Slow-release chlormequat (3MCAP-CYC) incorporated into peat-lite medium; sprays and drenches applied at 4th true leaf stage. Data 64 days after seeding.

x/ Measured midway between 1st and 2nd true leaf.

y/ Means in the same column followed by the same letter are not significantly different at the 5% level.

Petunia responses were similar although the enhancement of early bloom by low levels of 3MCAP-CYC was only 3-7 days as compared to the 2 weeks in tomatoes. Height control was again excellent when compared to the standard treatment commercially practiced by bedding plant producers (Fig. 2).

Figure 2. Height control in 'Happiness' petunias with controlled-release chlormequat vs. B-Nine sprays. *Above:* center plant grown in medium containing 3MCAP-CYC at 25g/1 with control plants on either side. *Below:* center plant sprayed with 2500 ppm B-Nine at silver dollar size with control plants on either side.

Pronounced height control in salvia and cleome are illustrated in Figures 3 and 4. It is readily apparent that plant producers can control plant height and size easily with 3MCAP-CYC incorporated in the growing medium. In many cases the control can be achieved concommittantly with enhanced earliness of bloom rather than the frequent delay achieved with standard commercial size-controlling techniques.

Levels of 6 grams or 12-1/2 grams/liter of peat-vermiculite medium stimulated rooting of 'Verns Delight' African violet cuttings. Root number was nearly doubled and the time at which cuttings were ready to be potted was advanced by 7 to 10 days. This preliminary information encouraged us to pursue further studies in rooting cuttings with controlled release chlormequat. In a series of experiments in which 'Irene' geraniums were rooted under intermittent mist, the early root number was increased by the 6 grams/liter rate, but by 15 days after sticking, the control cuttings were far superior in root number and root development of cuttings rooted in a 3MCAP-CYC-containing medium (Table 2)

Figure 3. Height control in 'Hot Jazz' salvia with controlled-release chlormequat. *Left to right:* 50, 25, 12.5g 3MCAP-CYC/1 peat-lite, and control.

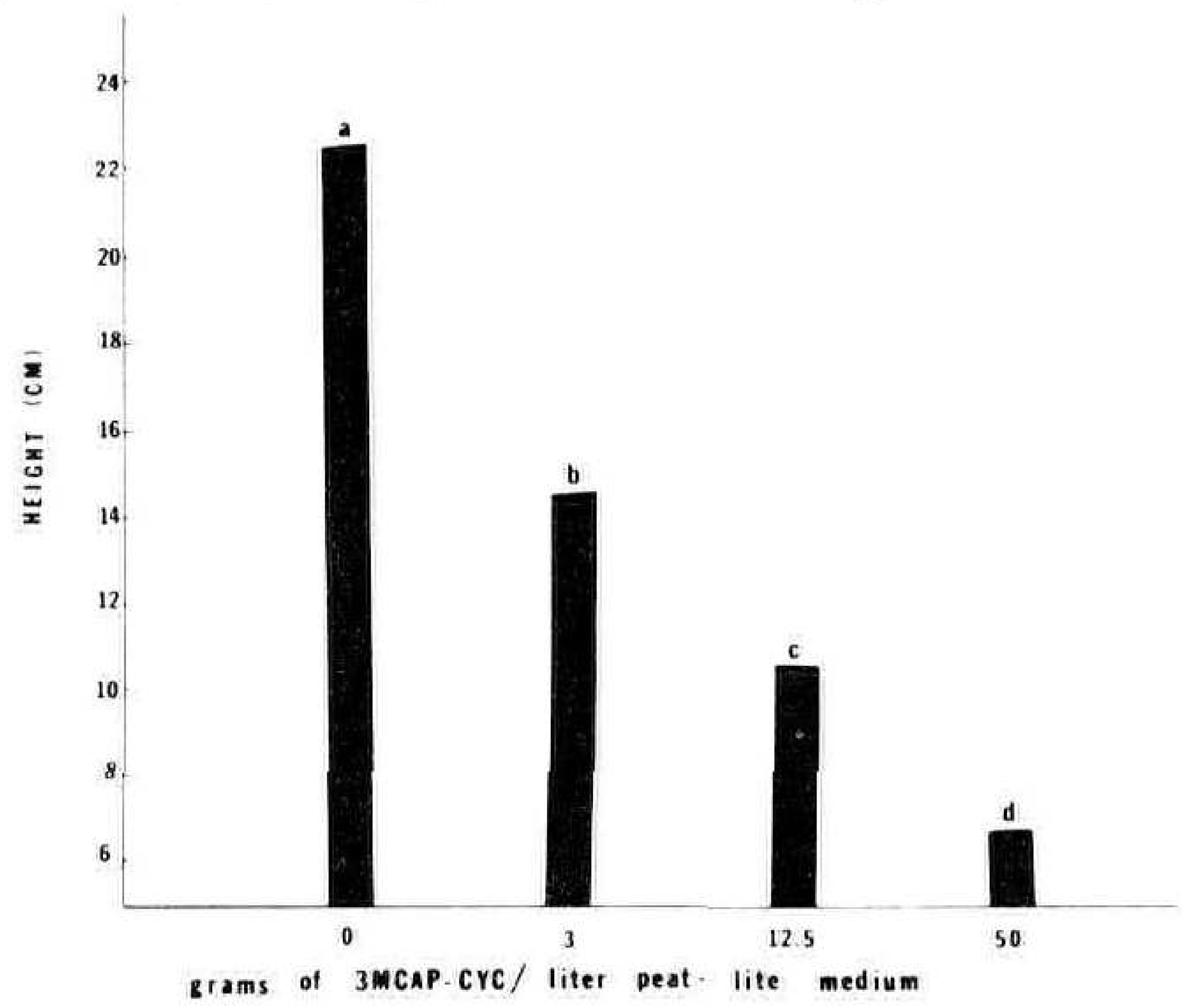

Figure 4. Height control in cleome 'Giant Rose Queen' with controlled-release chlormequat incorporated in the medium.

The results with geraniums suggest that although small levels of chlormequat can stimulate rooting of cuttings (1, 8) it is apparent that a continuing source of chlormequat in the rooting medium for geranium retards root development drastically. It is possible that release rates and application rates could, perhaps, be modified to solve this problem. However, it may be that the continuing source of growth-retarding chemical retards the growth of the plant too drastically and therefore will not be a satisfactory rooting stimulant. Further research is necessary to delineate the ramifications of use of 3MCAP-CYC for stimulating rooting of cuttings. It is also possible that other growth regulating compounds may be supplied to the base of the cutting through the encapsulation technique and possibly will be a more effective way of controlling rooting. Possible chemicals would include auxin-type materials and ethylene-releasing coumpounds, such as ethephon.

Table 2. Effect of controlled-release chlormequat on rooting of 'Irene' geranium.[z]

Grams 3MCAP-CYC/liter of medium	Root No. at 10 days	Root No. at 15 days
0	0	90
3	0	6
6	3	63
12	4	43
25	4	28

z/ Controlled-release chlormequat (4% formulation of 3MCAP-CYC) was incorporated into vermiculite rooting medium before sticking cuttings

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MODERATOR PATERSON: Thank you, Paul; we have time for a few questions.

JIM WELLS: Is this encapsulated CCC available?

PAUL READ: At this point it is experimental only; however there is a fair chance that it may be available within the next 3 to 5 yrs. Initially the material will probably be offered on the market as a component of pre-packaged media. The material seems to work best in non-soil containing media.

MIKE DODGE: Do you know of any work being done with encapsulated insecticides? This seems like it would be a very interesting area to investigate.

PAUL READ: I suggested this approach to the people who make our encapsulated cycocel but they have shied away from it primarily, I believe, because of the problems with clearance through E.P.A. It is a beautiful concept but with present regulations there would be considerable trouble getting approval for such a material.

MODERATOR PATERSON: Thank you very much Paul. Next we will hear from Dr. John McGuire concerning the difference in rate of uptake of IAA as influenced by the formulation.

EFFECT OF FORMULATION ON UPTAKE OF 3-INDOLEACETIC ACID IN CUTTINGS[1]

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Abstract. Talc formulations of IAA prepared by dissolving the auxin in alcohol were superior to talc formulations prepared by grinding IAA crystals with talc Similar concentrations of IAA in aqueous solution were taken up faster and produced more roots per cutting Maximum uptake in aqueous solution took place in 24 hours but talc formulations required 72 hours

When talc and ethanol formulations were compared on the basis of adventitious root production in *Ilex* cuttings, it required four and a half times as much IAA in talc to get the same amount of roots as obtained in ethanol formulations

REVIEW OF LITERATURE

Research devoted to methods of application of root promoting chemicals to cuttings has been extensive. As a result, two methods of application have come into widespread use: the concentrated aqueous dip and the talc dust (1, 2, 3, 5, 6, 7, 8, 9, 14, 15). Plant response varies, some responding best to concentrated dips while others give best results with talc dust applications (14, 15). Little information is available on rate of uptake as it is influenced by formulation. It is known that the liquid formulation is taken up in the transpiration stream by diffusion (10, 11, 15, 17, 18). There is less information about talc formulations although there is some evidence that talc alone will stimulate some root initiation (16). It is also known that effectiveness of talc formulation is dependent on the fineness of the talc particles (14).

INTRODUCTION

Further information is needed if a complete understanding of the effect of the carrier or formulation is to be obtained. If a li-

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