COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
Dorothy Conroy, Executive Secretary
909 Sherman Street, Denver, Colorado 80203

Bulletin 206 June 1967

Rooting of Carnation Cuttings

David W. Cheever[1]

Vigorous performance of carnation planting stock is an important factor in maintaining optimum production levels. Procedures used by propagators may contribute to subsequent performance. Research into the rooting phase of carnation propagation has never been done systematically. Most of the practices and environments used by propagators have been adopted by trial and error with little thought to final performances of the plant. Experimental evidence is needed to determine the effects of alternative methods to produce superior planting stock for the grower.

In September 1965, a meeting of Colorado propagators was held to discuss procedures that warranted study. As a result of this meeting, several major questions were selected for investigation. These questions concerned root inducing materials and their application, types of media, media temperatures, misting cycles, foliar feeding, and density of sticking.

Physiological factors such as root inducing substances and pH, aeration, and temperature of media were investigated first. Results from this research were incorporated with the remaining questions into factoral experiments to find interrelationships of the factors in question.

General Methods and Materials

The north half of a greenhouse was used for this research. A polyethylene film baffle 10 feet in height down the center of the house and across the fan end served to contain the mist and prevent excessive air movement. Four raised wooden benches were constructed 14 feet long and 6 inches deep. One bench was 3 feet wide, two were 4 feet and the fourth was 5 feet in width. These widths were designed to give the facilities flexibility in studying layout of mist lines and determining efficiency for commercial application. The bottom boards, 3 inches wide, were spaced 3/8 of an inch apart for adequate drainage.

Lead encased electric heating cables were laid at 6-inch intervals over a 1-inch layer of scoria. A layer of 3/4'' mesh galvanized hardware cloth was placed directly on these cables to spread the heat evenly. Media under test were placed on saran screen directly on the hardware cloth.

Mist was provided by ''Florida'' deflection nozzles tapped into 3/4'' galvanized pipe suspended 2 feet above the media. On the 5-foot-wide bench a double mist line containing 10 nozzles was used. The other 3 benches had single center lines of 6 nozzles. Movable fiberglass panels prevented drift between benches. Each mist line was connected to a solenoid valve. A mist timing device, gift of Fred C. Gloeckner & Co., was used to adjust intermittent mist cycles. This timer was restricted to daylight use by a 24-hour time clock. An electric cord connected to the solenoid valves could be plugged into one of six outlets on the timer for the desired mist interval and frequency.

Propagation Procedures

Carnation cuttings were broken from stock plants in such a way that the basal end always consisted of a section of internode (Fig. 1). This assures morphological uniformity of the tissue from which the roots initiate and develop. This method provides good connection between the new roots and the vascular system of the young carnation plant. No peeling or handling of the cutting base is required. Cuttings taken in this way can be handled more easily and inserted in the medium with a minimum of effort.

[1] This reports part of the work by David W. Cheever in partial fulfillment of the requirements for the Master of Science Degree in Horticulture.

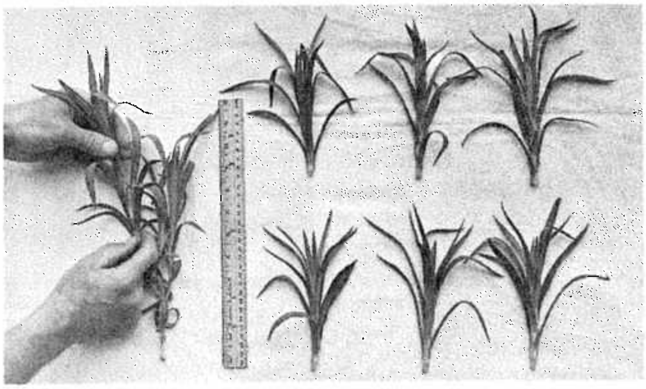

Fig. 1. Cutting removal by two-hand method (left) and lower row; upper row removed from stock plant by one hand.

As a result of tests with many commercial root inducing "hormone" preparations, as well as chemical compounds known to stimulate root development, the commercial product Jiffy Grow # 2 was selected for use. Jiffy Grow # 2 is a concentrated alcohol preparation consisting of the following:

Component		Concentration
NAA	a - naphthalene acetic acid	5,000 PPM
IBA	3 - indolebutyric acid	5,000 PPM
Boron	as boric acid	0.0175 %
PMA	phenyl mercuric acetate	0.01 %
Propylene glycol	(surfactant and solvent for PMA)	"small amount"
Alcohol	(90% ethanol and 10% isopropanol)	46 %

This mixture was diluted 1:15 with tap water and applied to the cuttings as a foliar spray on the first evening after they were stuck. The spray was applied after sunset so the aqueous solution could remain on the foliage for the maximum possible time. Mist on the cuttings at application time was removed by hand watering.

A peg-board was constructed by driving 2" cut nails through holes drilled in marine plywood at 1 1/2" spacing (Fig. 2). This board facilitated uniform spacing of cuttings at a constant depth, 64 per square foot. Benches were always steamed within 48 hours before a lot of cuttings were stuck. After sticking, the cuttings were watered in with a high volume, low pressure nozzle. A preliminary test showed that this procedure, a regular commercial practice, was important when rooting cuttings in horticultural perlite.

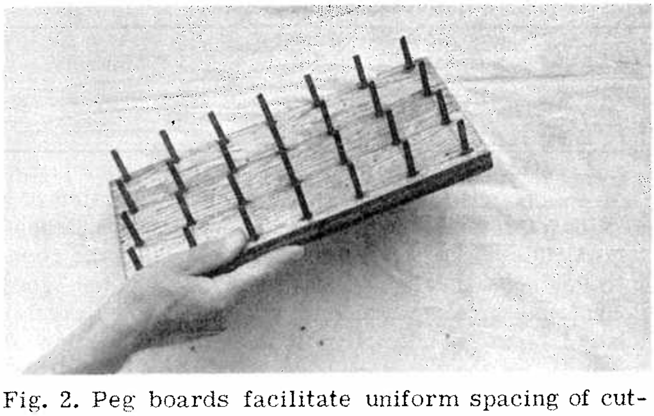

Fig. 2. Peg boards facilitate uniform spacing of cuttings at a uniform depth.

Intermittent mist was applied at intervals sufficient to maintain a constant water film on all leaf surfaces during daylight hours. The amount of mist actually delivered on cuttings was measured by placing test tubes adjacent to the cuttings and recording the accumulated water daily. This acted as a check on the system as well. If for any reason either too little or too much mist was applied, the fact could be recognized.

Experimental Design

A replicate consisted of 25 (5x5) uniform cuttings. The cuttings most heavily rooted were awarded 4 points each on a 4,3,2,1,0 grading system (Figure 3).

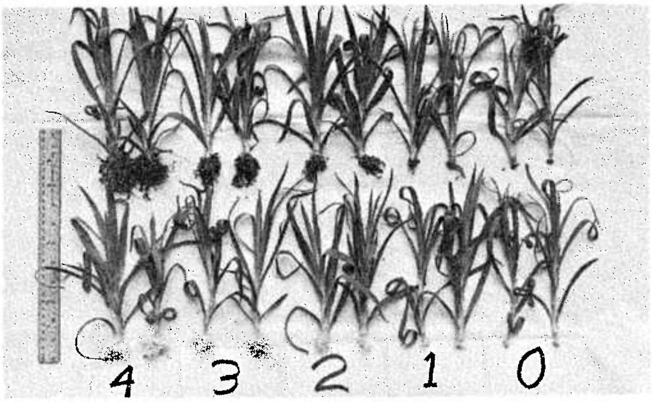

Fig. 3. Grading system used for obtaining rooting score: top row rooted in peat-perlite mix; bottom row rooted in perlite.

By using 25 cuttings as a sample, 100 points would be a perfect score. Each block of 25 cuttings was surrounded by sufficient buffer rows to eliminate border effects. Usually one row was considered sufficient. Whenever an extended time period of several hours was required for sticking or lifting cuttings, or for collecting data, operations were done by blocks to reduce within-block variation. Randomization of cuttings and plot locations was observed throughout.

Recovery Rate

Rooted cuttings from each treatment were randomized into 3 replicates of 12 cuttings each and planted in soil. After approximately one month of growth, plants were cut just beneath the bottom leaf pair and weighed to the nearest 0.1 g. Fresh weight was considered indicative of recovery rate in response to a given treatment during the rooting phase.

TABLE 1. Physical Properties of 12 Media and Rooting Score after 14 Days.

Medium	Mean score	% marketable	Medium Properties[1] pH	% Water	% Air
A. Horticultural perlite	72.8	65	6.2	41.7	36.7
B. Coarse perlite	56.0	39	6.1	32.9	47.5
C. Medium perlite	57.8	40	6.0	36.7	42.3
D. Medium coarse perlite	54.8	38	6.1	36.3	48.2
E. Fine perlite	63.5	57	6.7	59.7	23.3
F. Standard perlite	70.0	64	6.1	38.8	42.2
G. 9:1 Standard perlite, peat	58.0	38	6.6	41.2	44.5
H. 7:3 Standard perlite, peat	56.8	37	5.1	44.2	39.4
I. 4:1 Coarse perlite, peat	35.5	7	5.3	36.8	46.5
J. 3:2 Coarse perlite, peat	36.0	8	5.0	43.2	41.4
K. 2:3 Coarse perlite, peat	40.0	12	4.9	46.1	40.4
L. 1:1:1 Horticultural perlite, peat, Terragreen	82.0	83	6.3	45.2	37.0

[1]Water and air expressed as % of total volume at bench capacity.

Media

Aeration, water holding capacity, and pH were measured and correlated with rooting score obtained in 12 media. The following materials were used as components of these 12 media (Table 1):

Peat moss - Canadian sphagnum, pH 4.65, screened through 5 mm.

Horticultural perlite - Approximately 2 mm in diameter, commonly used for rooting cuttings under mist.

Standard perlite - A mixture of particle sizes, ranging from dust to 6 mm.

Coarse perlite - Particles retained on a 3 mm screen.

Terragreen - A brand of arcillite, particle size 1-4 mm.

Measurements were made of water and air contained in each medium at bench capacity, expressed as % of total volume. The measurements were made as follows:

1. For each medium, 4 replications of 3'' clay pots were soaked under water for 3 days, numbered and their capacity recorded in cc of water. Tare weight of the wet pots was obtained in grams.
2. Following weighing, each pot was filled level full with a sample of air dried medium and weighed.
3. The pots were then plunged to the rim in plots of the same medium and soaked under constant mist for 3 days. They were weighed at bench capacity and the water content calculated.
4. After weighing, each pot was plugged at the bottom and water added until visible at the top of the medium. The volume of water added was assumed to represent the open pore space.

The measurements were used for comparative purposes in order to reveal cause and effect relationships. The weights and measurements at bench capacity were made three times: before steaming, after steaming, and one day after lifting the cuttings. This would reveal changes taking place in a given medium as a result of steaming or of time under mist. pH measurements were made before sticking and after lifting cuttings.

Cuttings of Flamingo Sim were stuck August 11, 1966, 100 per medium plot and adjacent to the 4 pots. Intermittent mist was applied from 6 AM to 6 PM, using a 20-sec duration with an interval of 3.75 min. Average mist delivered per day was 3.7 cm. Bottom heat was not necessary during August. The cuttings were lifted after 14 days on August 25 and graded for rooting score.

Cuttings from two of the best scoring media were stored in plastic bags at 33° for 2 weeks and planted for recovery rate evaluation. The young plants were harvested 22 days later and their fresh weight, height, and number of visible lateral growths recorded. Correlation analysis was used to determine relationships between the three measurements.

Another set of cuttings from the same two media were kept 15 weeks in 33° storage and planted on December 10 to test for storage effects on recovery rate. The plants were harvested and weighed on January 14.

Results

The media affected root development as shown by rooting score and % marketable cuttings (Table 1). Particle size of the media affected aeration and water holding capacity only at the extremes (B and E). Rooting score was closely related to medium pH

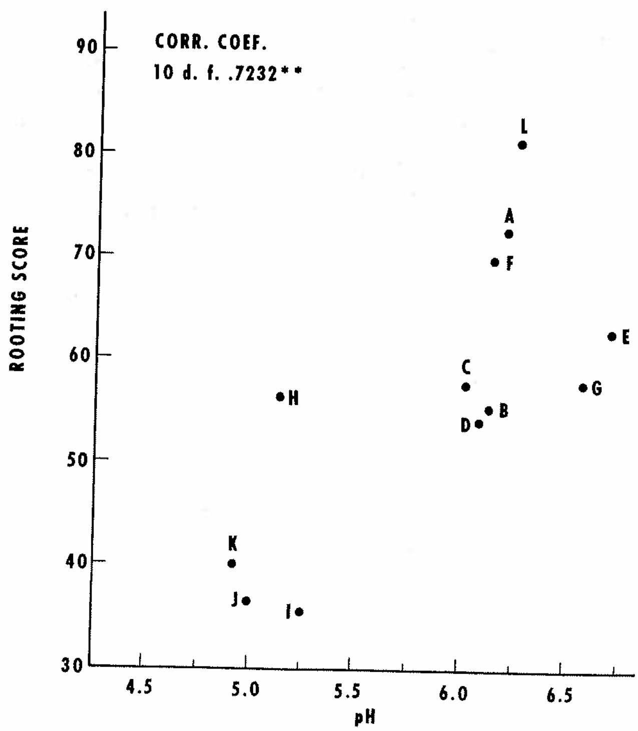

Fig. 4. Relationship of rooting score to pH in 12 media.

(Figure 4) but was not affected by air or water holding capacity of the medium.

Rooted cuttings from medium L recovered at a faster rate than those rooted in medium A whether measured as fresh weight, height, or number of visible breaks (Figure 5). All three measurements were equally reliable as criteria of recovery after planting. Cuttings from medium L were also superior in recovery after 15 weeks of storage (data not shown).

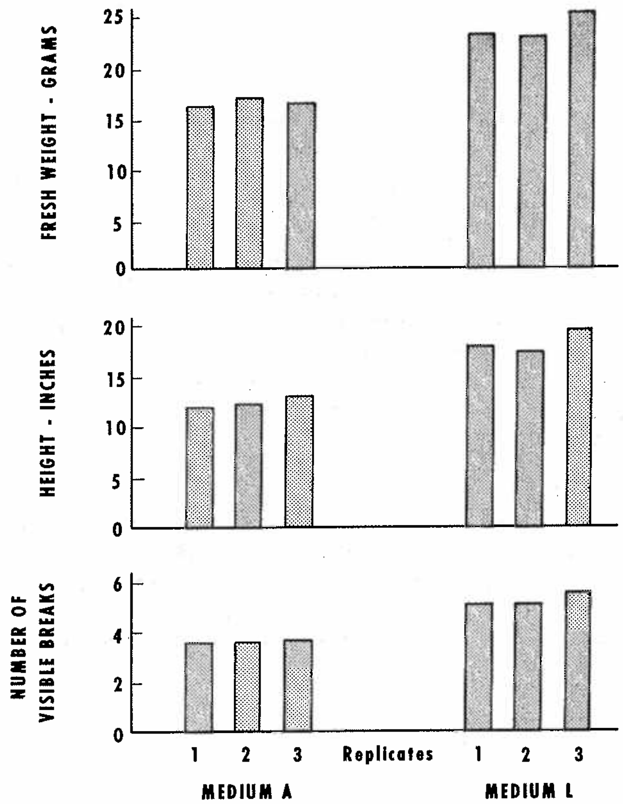

Fig. 5. Height, weight, and number of visible breaks one month after benching cuttings propagated in 2 media.

Media and Rooting Time

From the media study there was an indication that pH was correlated with rooting score. A pH near 7.0 seemed optimal. This experiment consisted of 6 media, ranging in pH between 6.0 and 7.25. Twelve plots were divided into 2 north-south blocks with the 6 media shown in Table 2 placed at random within blocks.

Cuttings were stuck in 3 groups, each 3 days apart. The first group, stuck on November 7, 1966, occupied the west third of a bench. The second and third groups were stuck in the central and east thirds, respectively. Cuttings of varieties S. Arthur and Gayety were randomized by sticking one complete row at a time across all 12 plots. A temperature of 70F was maintained in the media. Intermittent mist was applied from 7 AM to 4 PM, using a 15-sec duration with an interval of 3.75 min, delivering 2.1 cm per day.

All the cuttings were lifted on November 26 and graded for rooting score. There were 6 media treatments, replicated twice, and 3 day treatments for a total of 36 sample blocks. Cuttings from the three best media were planted out December 10 for recovery rate evaluation. There were 3 media and 3 days replicated 3 times for a total of 27 sample groups. Plants were harvested on January 14 and individual fresh weights recorded.

TABLE 2. Rooting score and percent marketable cuttings in 6 media at 3 time intervals.

Media	pH	Mean Score			Percent marketable		
		13 days	16 days	19 days	13 days	16 days	19 days
A. Horticultural perlite	6.8	67.0	72.5	89.5	70	78	100
B. 1-1-1 Hort. perlite, peat, Terragreen	6.3	63.5	79.0	81.0	56	88	80
C. 1-1-1 Hort. perlite, peat, Turface	6.2	57.5	71.5	88.5	42	80	94
D. 2-2-1 Hort. perlite, peat, Terragreen	6.3	52.0	63.5	78.0	20	54	78
E. 7-3 Hort. perlite, peat plus 50 g $CaCO_3/ft^3$	6.5	60.5	69.5	84.0	52	68	84
F. 7-3 Hort. perlite, peat plus 100 g $CaCO_3/ft^3$	7.2	76.0	78.5	88.5	82	88	88

Results

Both media and length of time in the propagating bench affected rooting score (Table 2) though there was no interaction between the two factors.

Rooted cuttings from media A, B, and F were planted out for recovery trial. Although the three had similar and generally superior rooting scores, it was important to determine whether cuttings from B or F performed best after planting. The better of the two could then be used in subsequent experiments. A, the medium currently employed by most propagators, served as a standard. Gain in fresh weight from unrooted cuttings (average weight 7 g) was affected by media and time in the propagating bench (Fig. 6). The interaction between media and time of recovery revealed that 16 day cuttings from medium F recovered as well as 19 day cuttings from all 3 media (Fig. 6).

DISCUSSION AND SUMMARY

Foliar application of root inducing substances has obvious advantages over any alternative. Contact of any kind with bases of cuttings is avoided, providing a step forward in sanitation. A step in handling is eliminated as a large area of cuttings may be treated quickly at one time. In large operations the chemicals might be injected into the mist in dilute quantities. Penetration of leaf surfaces in response to concentration gradients suggests that toxic quantities would not likely be absorbed from concentrations used for the desired rooting response. With the present methods, such as quick dips in alcohol or talc preparations, basal injury is not uncommon. Adequate spacing of cuttings should insure greater success with foliar sprays of growth regulators because of better contact with the lower mature leaves which serve as sources of assimilates for developing root areas.

The commercial preparation Jiffy Grow # 2 was applied to stock plants to test its effectiveness as a foliar penetrant. Sprayed plants exhibited stunting, shortened internodes, brittleness, and a reddish color of nodal stem tissue. Production of cuttings was reduced to half the number from check plants during the first month. These findings indicated leaf penetration actually occurred and that application of the compound to intact stock plants was detrimental.

Evening application, necessary because of the interference from mist during daylight, has several theoretical advantages. The applied solution should remain on the foliage for periods as long as 15 hours with high humidity (common to the greenhouse environment at night) being beneficial. Inactivation of the NAA should be minimal at night.

Propagation Media

Almost any medium may be used for rooting carnation cuttings. However, the present cultural practices involving storage of rooted cuttings, distance shipping, tight scheduling, and direct benching in minimum-care large scale production place restrictions and specifications upon suitable media. The experiments in this series showed that a combination of peat and perlite (1:2) plus sufficient limestone to neutralize the mixture is an excellent medium. It is light in weight enabling a reasonably large root ball to be handled and shipped with a minimum of root loss. Cuttings rooted in this mixture repeatedly made greater fresh weight gains after planting than those in perlite.

Although these experiments proved limestone, sufficient to neutralize the peat-perlite mix, made the difference between success and failure, the reasons for this are unclear. Perhaps acid peat extracts small but harmful amounts of aluminum from the perlite, a thermo-expanded aluminum silicate. Aluminum has been reported a "root poison" with concentrations as low as 6-16 ppm shown to cause root injury. There is also evidence for a Ca-Al antagonism, where high Ca concentrations reduce Al toxicity.

Paul and Smith (5) showed how the substitution of Ca^{++} for H^{+} in peat favors root development in chrysanthemum cuttings. Other studies support the evidence that Ca plays a vital role in root development (1, 2, 3, 4). Since Ca is immobile in the plant, newly formed roots must obtain this essential element from the medium. It is likely that the beneficial addition of limestone to the medium was due to Ca rather than to an effect of higher pH per se. Perhaps liming of perlite would improve its efficiency as a medium for carnation propagation should organic matter like peat be undesirable for future growing practices.

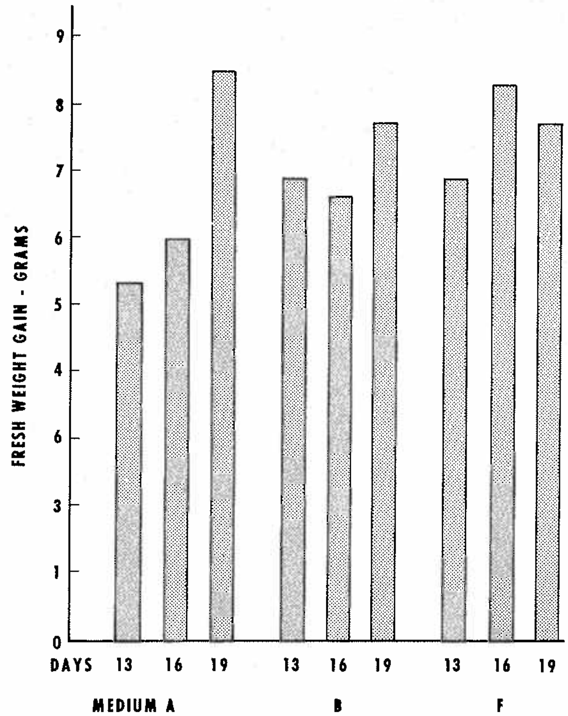

Fig. 6. Relative fresh weight gain 1 month after benching cuttings rooted in 3 media and removed from the propagation bed at 13, 16 and 19 days. The top 4 bars not significantly different according to Duncan's New Multiple Range Test.

Cuttings lifted from the peat-perlite mix appear to have their roots coated with fine particles of peat. This should act as an insulation against excessive root hair damage during handling and provide a reservoir of water during extended storage. Providing adequate drainage is available, peat contributes the benefits of high moisture retaining properties to combinations with inorganic mineral media.

Several interesting factors of secondary importance were observed during the course of the media studies. Small quantities of peat (5-15%) when added to perlite resulted in higher pH readings than observed in the straight perlite. Greater percentages resulted in a rapid drop in pH. Water holding capacity increased and air pore space decreased about 5% in most media during two weeks under intermittent mist. It is not known how this trend continues with time and which media are most affected. There was evidence that steaming increased pore space about 5% in perlite and peat-perlite combinations containing less than 40% peat. Perhaps steaming returns the air pore volume to original levels between each lot of cuttings. Mixtures containing peat are soft, facilitating the sticking of cuttings, and have no glare in bright sunshine, an offensive feature of perlite.

Data indicated that cuttings could be spaced somewhat closer in the peat mix than in perlite without detrimental effects. This trend was particularly true if an adequate, but not heavy, mist quantity was delivered. Extending the time in the propagation bench or overrooting resulted in some mechanical root loss in the mixture, especially at spacings closer than optimal.

Literature Cited

1. Burstrom, H. 1952. Studies on growth and metabolism of roots. VIII. Calcium as a growth factor. Physiol. Plant. 5:391-402.
2. ________. 1953. Physiology of root growth. Ann. Rev. Plant Physiol. 4:237-252.
3. Chapman, H. D. 1966. Diagnostic criteria for plants and soils. Univ. of Calif. Div. of Agr. Sci., Berkeley. 793 p.
4. Cormack, R. G. H. 1949. The development of root hairs in angiosperms. Bot. Rev. 15:583-612.
5. Paul, J. and L. Smith. 1966. Rooting of chrysanthemum cuttings in peat as influenced by calcium. Proc. Amer. Soc. Hort. Sci. 89:626-630.

Ed. Note--There will be several articles coming from Dave Cheever's work as space permits.

Recent and Good

New Lily Manual

Through the cooperation of the New York and Ohio Lily Schools held last fall, a most informative manual on the Easter Lily is available. Topics covered are history, breeding, bulb production, factors affecting flowering, bulb handling, and culture and timing. Also diseases, pests and marketing come in for their fair share of treatment. Almost all the important researchers on this crop contribute to the manual, an absolute must for the producer of bulbs or the forcer.

It can be obtained for $2.00. Make your check or money order to New York State Flower Growers Assn. and send it to Dr. Robert Langhans, Department of Floriculture, Cornell University, Ithaca, N. Y. 14850.

Don't Use Oils or Solvents on Plastic

Many of the pesticides purchased in the liquid form contain oil or solvents. These should not be used with most plastic or rubber products because they dissolve them.

We have learned of a few instances in which attempts have been made to use the Commander Fertilizer Injector to inject pesticide emulsions into irrigation water resulting in damage to the injector. This equipment is not designed for that kind of use.

Before spraying shading compound on film or rigid plastic greenhouses, make sure that it does not contain oils or solvents that will harm the plastic. (from Jed's Jottings.)

Your editor,

W D Holley

COLORADO FLOWER GROWERS ASSOCIATION, INC.
OFFICE OF EDITOR
W. D. Holley
Colorado State University
Fort Collins, Colorado 80521

FIRST CLASS