COLORADO FLOWER GROWERS ASSOCIATION, INC.

IN COOPERATION WITH COLORADO STATE UNIVERSITY
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Inert Media Compared for Carnation Growing

W.D. Holley and John Parker[1]

Greenhouse culture is rapidly progressing to the point where the soil used to grow plants functions primarily as support. When complete nutrient solutions are used for irrigation, the nutrient supply for plants is automatically taken care of when the water needs of plants are met. An experiment was completed during the 1966-67 crop year to compare three inert media and mixtures of these media for carnation growing. The 6 media listed in Table 1 were replicated in the four compartments of the CSU Temperature House under coverings of Frost and Clear fiberglass, clear PVC panels and glass. Differences due to greenhouse covering were not significant hence this data is not included in this paper. The media used with their relative water holding capacities follow:

Table 1. The 6 inert media under comparison with water holding capacities.

	Pounds free water held per gal. medium
Scoria	2.28
Scoria 80% Terragreen 20%	2.50
Scoria 40% Idealite 40% Terragreen 20%	1.87
Scoria 50% Idealite 50%	1.50
Idealite 80% Terragreen 20%	1.24
Idealite	0.70

The scoria used was from crushed volcanic rock including all fractions passing 5/8" mesh screen. Idealite is a lightweight aggregate manufactured by Ideal Cement Company from illite shale crushed and baked at around 2000°F. Fractions above 5/16" mesh and below 1/8" mesh were removed from the medium used in this study. Terragreen is the trade name for a calcined clay product (arcillite) manufactured by the Oil-Dri Corporation of America. Possible value of additions of this material to any inert medium were tested with 1/8" mesh product. Plot size was 2 by 3 1/4 feet replicated and randomized in the four compartments.

The media were steamed and rooted cuttings of the carnation variety "Coquette" were planted June 26 at 3 plants per ft^2. A peripheral watering system was installed to irrigate all plots simultaneously and was controlled by a solenoid and an electric timer. Water was applied daily throughout the experiment until there was slight drippage from the bottoms of the free-draining plots. Since the media held different amounts of water (table 1) some media would subject plants to more stress than others. The effects of this variation were one of the purposes of the investigation.

The nutrient solution supplied at each irrigation was the same being used on soils at the time and consisted of 2.7 lbs. ammonium nitrate, 3 lbs. potassium nitrate, 0.75 lb. 11-37-0 for phosphate, 0.5 lb. epsom salts, 0.25 lb. sodium nitrate and 1 ounce of borax per 1000 gallons. New Idealite is saturated with calcium but Scoria contains no available calcium. Five percent chipped limestone was incorporated in plots of Scoria or Scoria and Terragreen. No calcium deficiency symptoms were observed in any of the plots.

[1] A part of this work was completed by John Parker while a senior in Horticulture at CSU. Present address - U.S. Army

An analysis of tissue taken in May gave the results in Table 2.

Table 2. Tissue analyses from carnation plants grown ten months in 6 inert media and in CSU soil.

Media	Percent P	K	Ca	Mg	Na	S	N	Cl
Coquette								
S-T	.28	3.06	.65	.26	.16	.03	3.59	1.25
I	.26	3.35	.93	.38	.18	.08	3.39	1.38
S-I	.23	2.65	.80	.38	.20	.07	3.39	1.13
S-I-T	.24	2.35	.75	.31	.13	.05	3.28	1.13
S	.27	1.70	.80	.32	.20	.06	3.20	1.25
I-T	.24	2.60	.73	.36	.12	.06	3.25	1.25
CSU Red								
Old soil	.33	2.65	1.06	.16	.15	.21	3.56	1.25

Phosphorus levels were low, but possibly adequate according to the recent nutritional studies by Green. The highly variable potassium levels are not understood since all plots received the same nutrient solution. Potassium was especially low in plants growing in Scoria. Calcium levels were lower in the plants growing in inert media than in plants growing in CSU soil. All calcium available to the plants came from the medium since none was applied in solution. The lowest tissue calcium was in plants growing in Scoria and Terragreen. Magnesium levels were generally adequate and lowest in plants grown in soil. Sulfur levels were generally low in plants grown in inert media. Little sulfur was added in the nutrient solution. Sulfur was adequate in the tissue of soil-grown plants. Levels of nitrogen in all plants were adequate, at least from present knowledge.

While no soil plots were included in this experiment, adjacent plots of CSU Red Sim in soil were planted in the house on the same date. Faster growth and freer branching were apparent from the start in inert media. The first crop of "Coquette" was two weeks earlier and about 20% larger than that from "CSU Red" in the soil plots (Fig. 1). Rooted cuttings of Coquette benched June 26 and pinched once began flowering October 15, with the majority of the first crop produced during November. Figure 1 shows the distribution of first crops from 168 ft^2 of inert media and the same area in soil plots. The two varieties do not normally grow at the same rate. If anything, Coquette is somewhat slower than CSU Red.

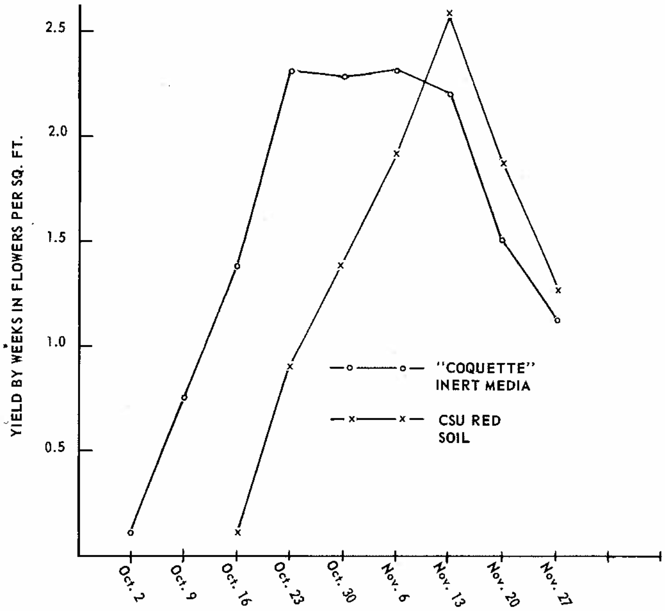

Fig. 1. Distribution of the first crop of carnations from rooted cuttings planted June 26: 1) "Coquette" in inert media, and 2) CSU Red in soil. Plants pinched once.

Yield and grade from Inert Media

Flowers were graded by SAF standards from October 2 to June 11. Yields by media are shown in Table 3. Twenty-eight ft^2 (4 plots) was planted to each medium. Differences in total yield between media were not significant. Scoria and the Scoria-Terragreen mixture produced more flowers of the design grade than the 4 other media and a lower mean grade of flowers than Scoria-Idealite or Idealite-Terragreen. These two media (S and S-T) held the most water (Table 1). Daily irrigation during winter probably reduced moisture stress below the minimum requirement. The percent of design grade flowers was higher on all of these plots than we would normally produce. In other words, the free and plentiful supply of water allowed the plants to grow too well. The percent of design grade flowers produced by two of the media is plotted in figure 2. The curve for Idealite was common to the media holding less water while the curve for Scoria was common to media holding relatively more water.

Table 3. Yield and grade of "Coquette" Carnation in six inert media.

Medium	Grade Design	Green	Red	Blue	Mean	Total Yield
S-I	103	58	419	455	4.18	1035
S-I-T	94	112	466	421	4.11	1093
S	133	67	435	414	4.08	1049
S-T	145	79	454	423	4.05	1101
I	106	83	454	400	4.10	1043
I-T	99	85	442	448	4.15	1074

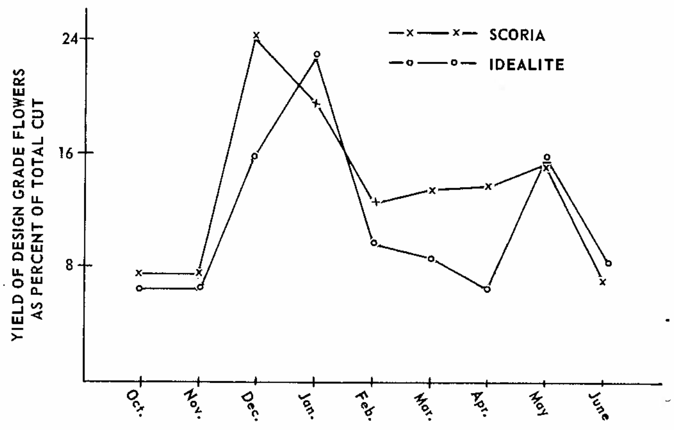

Fig. 2. Percent of design grade flowers of carnation "Coquette" grown in two inert media. Scoria holds 2 + pounds of water per gallon while Idealite holds 0.7 pounds.

Approximately 50% of the designs produced from October to December were bullheaded flowers. Fifty percent of the January and February designs were caused by split calyxes. Almost all of the designs produced in May and June were caused by calyx splitting. A substantial 25% of designs produced from November to March were caused by broken stems. Brittleness was a serious problem when growing this brittle variety under minimum moisture stress.

The distribution of design grade flowers by month and media is expressed as a percent of the monthly yield in Table 4. Note the two media holding the most water produced approximately 13% designs for the year.

Attempts to measure stem brittleness by the force in grams required to break stems at various points were unsuccessful. Brittleness of stem was a serious problem during the December to March period when air flow and moisture stress were minimal. Differences in brittleness due to media were not detectable. Controlled moisture and nutrient stresses are presently under investigation as means of eliminating brittleness. The predominant factor contributing to brittleness in this experiment is recognized as varietal.

Table 4. Monthly percent of design grade flowers produced by "Coquette" carnation in 6 inert media.

	Medium					
Month	S-I	S-I-T	S-T	I	S	I-T
Oct.	4.8	4.3	7.3	6.5	7.6	4.7
Nov.	5.9	7.7	15.7	6.2	7.5	7.5
Dec.	18.7	8.0	21.0	15.8	23.9	12.8
Jan.	20.3	17.1	12.7	22.4	19.5	11.5
Feb.	11.4	5.4	14.2	9.7	12.3	7.2
Mar.	8.1	5.8	11.6	8.8	13.3	7.4
Apr.	6.3	13.6	7.6	6.7	13.7	8.1
May	15.7	12.0	16.7	15.8	14.4	17.6
June	17.2	15.8	2.6	8.8	7.1	7.9
Mean	10.0	8.6	13.2	10.2	12.7	9.2

Summary

The remarkable point made by this study was the uniformity of results that can be expected from different inert media. Yields were essentially the same even though some of the media were overwatered and others were underwatered, at least a part of the year. Differences in quality and grade were largely due to moisture and nutrient stress and should be controllable. From the experience so far obtained with growing in inert media we feel that 1) establishing the correct irrigation frequency for a given medium is all important, and 2) the nutrient solution presently in use by most growers may require minor modifications to produce maximum results. Tissue analysis is a guide to this modification.

Moisture stress should be minimal during the 8 months of the year when solar energy is high. Some stress must be provided during the darker months when houses are closed much of the time. Stress may be easier to control by increasing or substituting certain nutrients in the winter period rather than by decreasing watering frequency.

Estimating Watering Frequency for an Inert Medium

W.D. Holley and Joe J. Hanan

A useful method for measuring the free water that a medium will hold is to weigh a standard container such as a 1-gallon can, fill with the medium to be tested and weigh again. The medium should be reasonably dry when weighed but not necessarily air dried. Fill the can of medium with water, allow to set for a few minutes, punch holes in bottom of container and allow thorough draining. A final weight of the wet medium will allow a rough calculation of the weight of water adhering to this known volume. The weights in pounds of free water held by a gallon of several media follow:

Fort Collins loam	1.8
FC loam-sphagnum peat 1:1	2.3
River sand 1/4" mesh	1.8
River sand-sawdust 1:1	2.3
Scoria 5/8" minus	2.3
Idealite 1/8" to 5/16" grade	0.7
Sand-peat-loam 1:1:1	2.4

The size and porosity of the particles govern to a large extent how much water is adsorbed to inert media. The grade of scoria tested here contained all particle sizes below 5/8" mesh. If the 1/8" mesh were removed, it probably would hold little more water than Idealite. Coarser grades of Idealite hold even less water than the one tested here.

Almost any inert medium can be used successfully provided it is nontoxic. Watering frequency must be related to the water holding capacity of the medium. The less water held, the more frequent a medium should be irrigated.

Our most recent experience with Idealite in Colorado has indicated that carnation cuttings benched in early summer should receive applications of nutrient solution 4 times daily until about mid-August. The irrigation frequency should be gradually reduced until by November 15 the plants are watered once daily. Sufficient water should be used to "drip the bench" with the Gates system on an 8" Idealite bench. The time should not be more than 2 1/2 minutes. Once daily watering from November 15 to March 1 should be adequate. Occasional days during cloudy periods may be skipped without damage to the plants. When reducing irrigation frequency, always drop off the last irrigation of the day so that plants will have more time to dry off. Watering frequency should be increased to twice daily in March, keeping the same watering time per application. Three or even four waterings per day may be needed during summer with older plants. With these loose, open media overwatering is not expected to be a problem when light is plentiful. On the other hand, underwatering will result in reduced growth.

While this method of growing will result in greatly increased growth, it will require more water and more nutrients. Accumulations of salts in the media have not occurred so far so irrigation time should be reduced to that barely necessary to start benches to dripping. Any additional drainage would be a serious waste. If salt accumulations become a problem, leaching should be done with untreated water.

The grade of scoria reported here could be watered one-third as much. Watering frequencies for other media could be estimated from their water holding capacities.

Carnation Timing is Affected by Inert Media

W.D. Holley

Carnation cuttings were benched in scoria-Idealite on June 28 and in Idealite on July 3. Three benches of soil were also planted with rooted cuttings on July 3, 1967. Several clones of the Sim variety were used. Plants in the two inert media were watered 4 times daily to August 29, 3 daily to September 15, 2 daily to October 15, and once daily to March 1. Plants in soil were watered when the soil appeared dry to the touch, approximately on 6- to 8-day intervals.

Figure 1 shows the distribution of the first and most of the second crops in inert media. Somewhat less of the second crop has been cut from the soil grown plants. While the grade of flowers has been superior from inert media, this data will be more meaningful at the end of the season.

The June 28 planting in inert media was too early for Christmas while the July 3 planting was earlier than we would like. Later plantings (not included) to July 15 were timed well for Christmas but growth was considerably less on carnation cuttings planted as late as July 15.

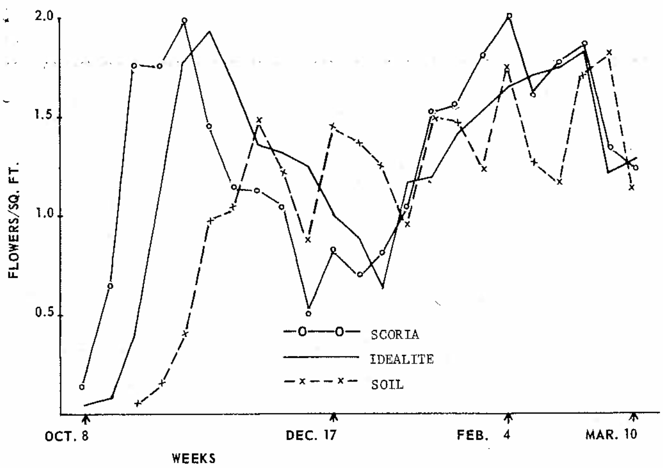

Fig. 1. The effects of growing medium and irrigation frequency on timing of first and second carnation crops.

Instead of planting later in inert media, it is suggested that cuttings be planted in late May or early June. In this way advantage can be taken of the long days and high solar energy. Additional pinching can be done to build a larger plant. A good percentage of fancy flowers can be cut from the first crop that will have adequate time to return for spring.

When the second crop is cut from January to March as was done on these two plantings in inert media, there were no lateral breaks present. Although steady production at around 1 $/ft^2/wk$ is predicted for these plants until June, no large crop will be produced again before summer. The cropping of single pinched plants in soil is somewhat more dispersed and does not accent this problem of low production following the second crop. Second pinching of young plants in inert media should help alleviate this problem.

Recent and Good

The following abstracts are from papers presented at the Eighth National Agricultural Plastics Conference, San Diego, Calif., February 20-22, 1968. Additional information on each topic should be available from the authors.

Double Covering a Film Greenhouse Using Air to Separate the Layers

William J. Roberts
Rutgers University
New Brunswick, N. Y.

Double covering of plastic film greenhouses is not new. The traditional approach is to use a 2 x 2 spacer and a 1 x 2 nailing strip with various methods of attachments.

Being tested is a new way of achieving the same effect at less cost in time and materials. Two layers of 4 mil polyethylene film are applied together and fastened at the 4 outer edges. This usually means sealing at the end rafters and at the ridge and sill.

Once the plastic is applied, a small blower is used to force the layers of plastic apart with air. This gives a quilted air mattress effect. The inner layer of plastic is forced down over the rafters and the outer layer assumes a gothic or quonset shape.

This "bubble" converts the loose film to a rigid plastic house. Both the spacer and nailer are eliminated, reducing the shade in the house. The blower is very small and economical to operate. The pressure within the bubble is maintained at 0.2" to 0.3" static pressure.

Fiberglas Surfaced with "Tedlar" PVF Film for Greenhouse Covering

Donald D. Wilson
E. I. du Pont de Nemours & Co.
Wilmington, Del.

Glass reinforced polyester is an attractive material for the design of a greenhouse to control environmental factors. "Tedlar"* polyvinyl flouride film laminated to polyester sheets provide a tough chemically inert surface capable of withstanding the effects of weather and corrosive materials. Weathered translucent panels clad with UV opaque "Tedlar" have retained uniform light transmission and color and have exhibited no fiber bloom and dirt buildup. The PVF surface can be easily cleaned and should require only minimal maintenance for many years. The film provides a stable surface for the application and removal of colorants to modify the panel spectral transmission. There is an up-charge for the "Tedlar" clad panel which we feel can be justified by extended functional service life and lower maintenance cost.

*Du Pont registered trademark

The Use of Inflated Plastic Greenhouses for Controlled-Environment Agriculture

Carl N. Hodges, John E. Groh
and William Johnson
University of Arizona
Tucson, Ariz.

Theoretical design equations, construction details, and experimental results from the Rockefeller sponsored University of Arizona research and development program for power, water and food production in coastal desert areas are presented. For the last year, the University of Arizona has operated two completely inflated experimental greenhouses in Puerto Peñasco, Sonora, Mexico. These units are fabricated from a single piece of 10 mil, 40 ft. by 100 ft. polyethylene film. The houses were destroyed several times during high wind storms, but eventually a design was evolved which is now believed to be stable in winds up to 70 miles per hour, and considerably higher when stronger plastics are utilized.

Increased Yields through the Use of Plastics for Greenhouse Tomato Production

Merle H. Jensen
Rutgers University
New Brunswick, N.J.

Three greenhouse tomato hybrids were grown in a plastic greenhouse and compared for average fruit weight, percent total yield of number 1's, 2's and culls and total marketable yield. The hybrids tested were Michigan-Ohio, Tuckcross O and Veegan.

For added control of those diseases that often lower yields of greenhouse tomato production the following procedures were used:

1. Two growing systems were selected, ring and trough culture, with a growing media of sphagnum peat and vermiculite.
2. The growing beds were lined with a black polyethylene mulch with the ring culture container made of a clear polyethylene.
3. The entire floor of the greenhouse was lined with an opaque-white plastic for three reasons:
   (a) to separate the disease area from the growing area

(b) decrease evaporation of moisture from the soil to the greenhouse environment which in turn helped to control humid conditions in the greenhouse, and

(c) light reflection.

4. Heat distribution and continuous air circulation were accomplished with the aid of metal ducts and plastic ventilation tubing. Cool fresh outside air was introduced into a plastic tube for even distribution throughout the greenhouse with the amount of air taken in controlled by an exhaust fan wired to a time clock.
5. The watering systems were of the kind that did not spray water on the tomato plant and were made of plastic.
6. The twine used for training the tomato vines was made of plastic.

Average yields of over 21 lbs. of marketable fruit per plant were recorded during a harvest period of three months. No disease problems were encountered, including tobacco mosaic virus.

Manganese Toxicity of Chrysanthemums

Commercial chrysanthemum growers have occasionally encountered poor growth, chlorosis and dieback which has not appeared to be due to disease or normal cultural problems. Manganese toxicity has been suspected in these cases and has been confirmed by high manganese content of the leaves of such plants.

During 1965 and 1966, Dr. A. L. Brown of the Department of Soils and Plant Nutrition at Davis cooperated with us in some greenhouse experiments designed to learn more about manganese toxicity of chrysanthemums following soil steaming.

In the first experiment, an unamended Sorrento Clay Loam was used with steaming treatments of 1/2 hour at 180°F and 1 hour at 212°F in an autoclave. In the second experiment, a mixture of 1/2 redwood sawdust and 1/2 Campbell Silty Clay was composted for four months, then steamed in the greenhouse for 1 and 4 1/2 hours respectively. Additions of lime, phosphate, chelated iron, and manganese were made singly and in combinations. Plant height, dry weight and concentrations of manganese in leaf tissue were measured.

Some of the findings in the two experiments were as follows:

1. Steam sterilization when no manganese was added increased plant growth in both experiments. Temperature and time of steaming did not result in differences between steamed treatments.
2. Steam sterilization at all times and temperatures increased manganese concentrations in the leaves. Although this was more notable when manganese was added, it also occurred with the field soils.
3. Applications of manganese reduced the growth of "Good News" and "Detroit News" but not of "Albatross." Depressed growth and chlorosis were more noticeable following steaming.
4. Applications of lime, phosphate and chelated iron had little or no effect on plant growth or concentrations of manganese in plant tissues.
5. For "Good News" and "Detroit News," the critical concentration of manganese in leaf tissue appeared to be approximately 800 ppm. "Albatross" was not affected at concentrations up to 1700 ppm. "Albatross" did not develop as high concentrations of manganese in the leaf tissue following steaming as did the "News" cultivars.

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Your editor,

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