AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture

B. SECONDARY: Plant Physiology

2. TITLE AND SUBTITLE

Trickle irrigation and media effects on growth of Chrysanthemum morifolium Ramat

3. AUTHOR(S)

Stern, J.H.; White, J.W.; Cunningham, R.L.; Cole, R.H.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1973	7 p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Department of Agronomy, Pennsylvania State University.
University Park, Pennsylvania 16802

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)

(In International Society of Horticultural Science. Technical Communications, v. 38, pp.1975-1982)

9. ABSTRACT

Trickle irrigation applies water to a fraction of the soil surface under low pressure (1×10^6 Dynes/cm^2) at frequent intervals, and prevents moisture stress. A grid of 1.27 cm polyethylene tubes with outlets every 40 cm (or greater, depending on the crop) has been used to apply water by trickle irrigation crops. With Dupont "Viaflo" spunbonded polyethylene irrigation tubing, water can be banded like fertilizer throughout the complete length of the tube. A complete nutrient solution can be injected sinto the irrigation water to eliminate water and nutrient stresses. With this system of irrigation, the supply of air to roots can become a limiting factor in soil. By using media of large particle size, lack of aeration can be reduced. Thus optimum growth takes aplace when air, nutrients, and water are present in optimum proportions in the rhizosphere for the crop being grown. The objective of this study was to evaluate the effect of particle size and irrigation frequency on the growth of Chrysanthemum morifolium Ramat., using a complete nutrient solution as irrigation water and incinerated anthracite refuse (IAR) and Gatesburg sand as media. The effects are detailed and discussed in this report.

10. CONTROL NUMBER: PN-AAB-880

11. PRICE OF DOCUMENT:

12. DESCRIPTORS

Chrysanthemums?
Growth
Nutrients
Soil texture
Trickle irrigation

13. PROJECT NUMBER:

14. CONTRACT NUMBER: CSD-1932 211(d)

15. TYPE OF DOCUMENT:

AID 590-1 (4-74)

635.93355
S839a

Penn State
CSD-1932
931-11-130-109
PN-AAB-880

TECHNICAL COMMUNICATIONS OF THE
INTERNATIONAL SOCIETY FOR
HORTICULTURAL SCIENCE

Section "Plant Substrates"
Chairman Prof. Dr. F. Penningsfeld

PROCEEDINGS
SYMPOSIUM
ARTIFICIAL MEDIA IN HORTICULTURE

Ghent, 10-13 September 1973

Editor
M. De Boodt

A.I.D.
Reference Center
Room 1656 NS

TRICKLE IRRIGATION AND MEDIA EFFECTS ON GROWTH OF *CHRYSANTHEMUM MORIFOLIUM* RAMAT.[1]

by

J.H. Stern, J.W. White, R.L. Cunningham, and R. H. Cole[2]
Agronomy Department, Pennsylvania 16802

Introduction

Trickle irrigation applies water to a fraction of the soil surface under low pressure (1×10^6 Dynes/cm^2) at frequent intervals, and prevents moisture stress. A grid of 1.27 cm polyethylene tubes with outlets every 40 cm (or greater, depending on the crop) has been used to apply water by trickle irrigation to field grown crops. With DuPont "Viaflo" (E.I. DuPont DeNemours and Co., Wilmington, Del.) spunbonded polyethylene irrigation tubing, water can be banded like fertilizer throughout the complete length of the tube. A complete nutrient solution can be injected into the irrigation water to eliminate water and nutrient stresses. With this system of irrigation, the supply of air to roots can become a limiting factor in soil. By using media of large particle size, lack of aeration can be reduced. Thus optimum growth takes place when air, nutrients, and water are present in optimum proportions in the rhizosphere for the crop being grown (9).

The objective of this study was to evaluate the effect of particle size and irrigation frequency on the growth of *Chrysanthemum morifolium* Ramat., using a complete nutrient solution as irrigation water, and incinerated anthracite refuse (IAR) and Gatesburg sand as media.

---

[1] The authors gratefully acknowledge support from The United States Agency for International Development (U.S.A.I.D.), through a 211(d) grant to the Agronomy Department at The Pennsylvania State University. The information and conclusions in this paper do not necessarily reflect the position of AID or the U.S. Government.

[2] Research Assistant, Associate Professor of Floriculture, Associate Professor of Soil Genesis and Morphology, and Associate Professor of International Agronomy, respectively.

Experiment Station Journal Series N° 4561.

Materials and methods

On June 30th, 1972, *Chrysanthemum morifolium* Ramat. cuttings of the cultivar "BGA Southern Comfort" were planted in two "V" bottom greenhouse benches 1.14 by 10.7 m, each divided into 12 plots 88.9 by 114.3 by 15.2 to 22.9 cm. A randomized complete block design with 3 replications including all combinations of daily, 4-hour, and constant irrigation with coarse IAR, fine IAR, and Gatesburg sand (4) were used except that daily irrigation was not used with fine IAR due to limits of space (Table 1). While the amount of water used per day was not identical for all treatments, more than adequate amounts of irrigation solution were used to prevent nutrient deficiency since plants do not absorb nutrients in the same proportions as the solubility of the nutrient compounds.

TABLE 1

Amount of Water Applied to Media

Media	Four Irrigations		
	One Irrigation at 0600 (l)	Beginning at 0600 at 4-hour Intervals (l)	Constant Irrigation Beginning at 0600 Ending at 1900 (l)
Coarse IAR	22,8	7.6	28.5
Fine IAR	Not Determined	7.6	28.5
Gatesburg Sand	22.8	7.6	28.5
Total per Day	22.8	30.4	28.5

The typical composition of anthracite refuse from central Pennsylvania is : 50 to 75 % SiO_2, 30 to 37 % Al_2O_3, 3 to 10 % Fe_2O_3, 1 to 2 % TiO_2, 1 to 2 % CaO, 0 to 1 % MgO, 1 to 3 % K_2O and Na_2O, and 0 to 1 % SO_3.

Water retention was determined at 0, 10, 30, 50, 80, 100, 500, and 1000 cm of water for each of three media using Tempe Pressure Cells (Soilmoisture Equipment Corp., Santa Barbara, California).

The dry sieve technique was used to determine summation particle size distribution curves for particles larger than 0.05 mm from a 2 Kg sample. The hydrometer method was then employed to determine the percentage of silt and clay in the remaining material (2). Samples of each of the three media were submitted to the Merkle Soil and Forage Testing Laboratory (Pennsylvania State University) for soil analysis.

Chapin Ooze irrigation headers (Chapin Watermatics, Inc., Watertown, New York) were used with the daily and 4-hour irrigation system. DuPont "Viaflo" (E.I. DuPont DeNemours and Co., Wilmington, Del.) spunbonded polyethylene irrigation tubing 7 m long was used with the constant system. Nine Cole-Parmer Masterflex (Cole-Parmer Instrument Company, Chicago, Illinois) variable-speed tubing pumps with 113-liter tanks were used to pump irrigation solution into the "Viaflo" tubing. A Rainbird Rain Clox (Rainy Sprinkler Sales, Peoria, Illinois) controller with solenoid valves directed irrigation solution for 12 min. to the daily irrigation system and 10 min. to the 4-hour system.

A modified Baker's solution was the irrigation solution for this study (1). The potassium level was 5 times that of Baker's solution since chrysanthemums require high amounts of potassium. Correction was made in the solution for the amount of calcium and magnesium in the tap water used. Calcium nitrate, magnesium sulfate, monopotassium phosphate, potassium sulfate, Nutra-min (E.C. Geiger, Harleysville, Pa.) enriched with borax and iron (Sequestrene 330 Fe) were used to produce the following concentrations: 140 ppm N, 15 ppm P, 95 ppm K, 200 ppm Ca, 24 ppm Mg, 3 ppm Fe, 0.5 ppm B, 0.25 ppm Mn, 0.01 ppm Cu, 0.14 ppm Zn, and 0.0014 ppm Mo. This solution was injected into the 4-hour and daily systems using 2 Merit injectors (Merit Industries Inc., Craston, Rhode Island) in series (one injected $Ca(NO_3)_2$ while the other supplied the other salts). Fertilizer of the constant system was mixed directly in the 113-liter tanks. The stock solution had a pH of 7.0 and a conductivity of 71 millimhos/cm.

Monocalcium phosphate was preplant incorporated at the rate of 4.25 Kg m^{-3} to prevent the media from removing excessive amounts of phosphorus from the solution, as recommended by Kiplinger (8). After 40 hr. of constant leaching the pH of the leachate ranged from 6.65 to 7.2. The media was steam pasteurized with free flowing steam for 1.5 hr. until all points in the bench reached a minimum of 82 °C.

The 66 rooted Chrysanthemum cuttings per plot were cultured according to commercial practice for "Standard" cut Chrysanthemums with modifications described above.

Plant height, fresh weight, and flower diameter were measured for more than 50 samples per plot. Seven subsamples from each plot were randomly taken for the determination of dry weight. Plant height in centimeters was measured from ground level to the tip of the meristem. Fresh weight in grams was the total weight of the stem, leaves, and flower immediately after harvest determined with a Mettler P1200 electric balance. Flower diameter in centimeters, was the maximum distance across the petals of the flower.

Typical wholesale commercial harvesting practices were followed in this study: as flowers became mature they were harvested irrespective of treatments. The seven subsamples used for dry weight determinations included the total above-ground parts and were oven-dried at 60 °C for 48 hr. and then weighed 48 hr. after removal.

Results and discussion

Summation particle-size distribution curves are presented in Fig. 1. While producing good Chrysanthemum growth, the media used in this experiment do not meet the size specification for preferred inert media as defined by Hanan (7) because the coarse IAR contained 11.5 % of particles smaller than 0.3 mm, the fine IAR 23.3 %, and Gatesburg sand 70.0 %, while Hanan indicates that less than 1 % of this material was desirable.

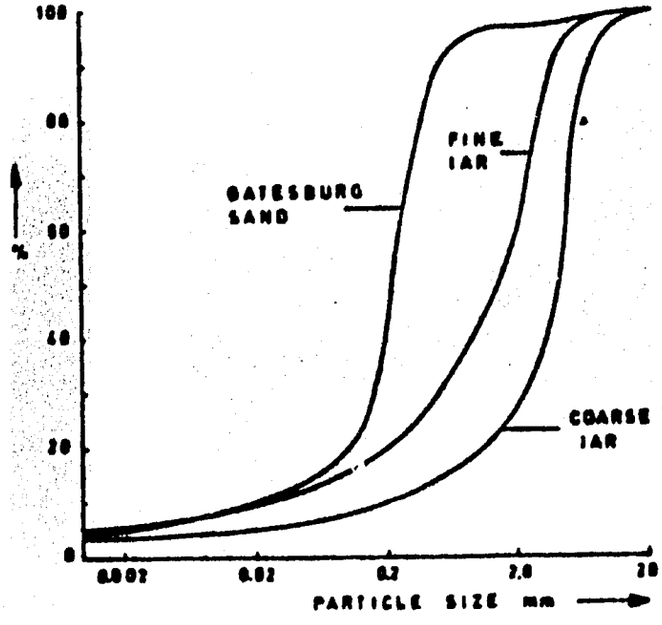

Fig. 1. — Summation Particle Size of Media.

The water retention curves (Fig. 2) plot water content in percent by volume against media matric tension in centimeters of water. By taking the values for 17 cm for water from the water retention curves and calculating the number of liters of water retained per square meter, the following values were obtained:

for coarse IAR, 57.5 l m^{-2}; fine IAR, 44.7 l m^{-2}; and Gatesburg sand, — 72.8 l m^{-2}. Hanan recommended 18 to 23 l m^{-2}.

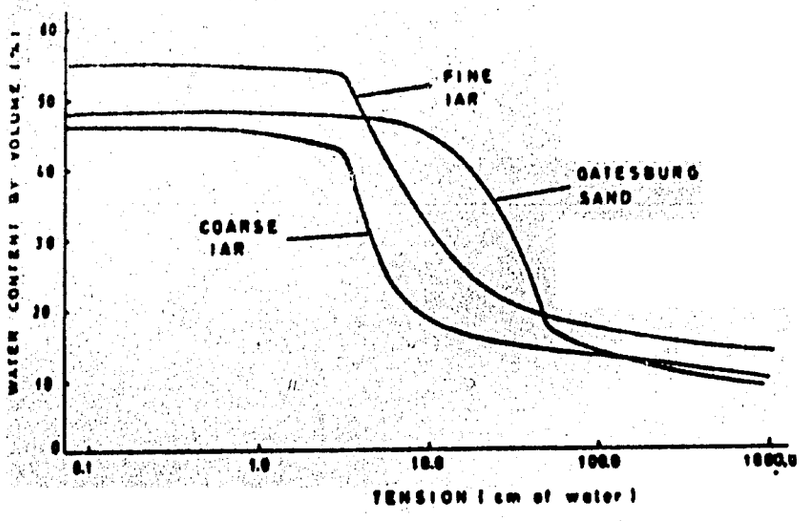

Fig. 2. — Water Retention of Media.

The results of soil tests conducted at The Merkle Soil and Forage Testing Laboratory, as presented in Table 2, indicate that these media contain 6 to 14 % silt and clay and would be able to supply some cations to plant roots.

The complete nutrient solution flowed through the 4-micron-diameter holes in the walls of the "Viaflo" tubing and did not plug. Algae growing in the nutrient solution did occasionally plug the plastic tubing leading to the "Viaflo" tubing before the plastic 113-liter tanks were coated with aluminum paint.

Harvest began 78 days after planting and continued at an increasing rate until completion, 84 days after planting. According to The Society of American Florists Grading System, the highest grade for cut Chrysanthemums is titled standard. Standard cut Chrysanthemums weigh from 85 to 127.5 g, have a flower diameter of at least 14 cm, and have a plant height of 76.2 to 106.7 cm. This standard was used to evaluate flowers in this experiment. Means of plant height of all Chrysanthemums produced in this experiment were greater than 106.7 cm, the maximum required for the standard grade (Table 3). This indicated that the flower induction period could have begun one week earlier. Hanan pointed out that time to anthesis in carnations could be reduced by 1 to 3 weeks by using inert media. 'BGA Southern Comfort' is listed in commercial

TABLE 2

Soil Analysis Data for Coarse IAR, Fine IAR and Gatesburg Sand.

Medium	% of Sample < 2 mm	% of Sample <0.05mm	CEC	Soil pH	Buffer pH	% Saturation		
						K	Mg	Ca
Coarse IAR	27	6	10.7	4.3	6.6	2.4	9.7	54.0
Fine IAR	60	13	7.2	5.3	6.5	1.5	4.1	24.3
Gatesburg Sand*	97	14	5.1	5.7	6.7	1.5	5.8	34.3

* Monocalcium phosphate was preplant incorporated at the rate of 4.25 Kg m^{-3} to Gatesburg sand before a sample was taken for analysis.

TABLE 3

Height, Fresh Weight, Flower Diameter and Dry Weight of 'BGS Southern Comfort' Chrysanthemums (means of 3 replications).

Treatment	Medium	Irrigation	Height* (cm)	F. Wt.* (g)	Fl. D* (cm)	Dry Wt.* (g)
1	Coarse IAR	Daily	114.6 ef	87.7 e	13.7 c	17.4 a
2	Coarse IAR	4-hour	118.7 cd	99.5 d	14.2 b	18.7 a
3	Coarse IAR	Constant	123.8 bc	108.3 c	14.1 b	20.4 a
4	Fine IAR	4-hour	126.1 b	119.6 b	14.5 a	22.4 a
5	Fine IAR	Constant	135.4 a	132.5 a	14.7 a	20.7 a
6	Sand	Daily	109.8 e	80.7 e	13.1 d	20.6 a
7	Sand	4-hour	121.2 bc	107.3 cd	14.2 b	19.6 a
8	Sand	Constant	124.0 bc	108.0 c	14.0 b	21.6 a

* Means within a column followed by the same letter are not significantly different at the 5 % level as determined by Duncan's Modified (Bayesian) Least Significant Difference Test.

catalogs as a '10 weeks' chrysanthemum, but in this experiment it flowered in just 7 weeks of short days. Early anthesis has been a significant finding in other trickle irrigation and inert media research (3, 5, 6, 7).

Gatesburg sand irrigated daily produced flowers with a mean fresh weight of 80.7 g and flower diameter of 13.1 cm, below the standard grade, while treatment 5 (fine IAR irrigated constantly) produced flowers with a mean flower weight (132.5 g) greater than that required for the standard grade.

The tallest and heaviest plants were produced in treatment 5 (constant irrigation on fine IAR). Treatments 4 and 5 produced the largest flowers. Within the two irrigations used on fine IAR, there were significant increases in plant height and fresh weight, but not a significant increase in flower diameter, under constant irrigation. Plant height and flower diameter were significantly lower in treatment 6 (daily irrigation on Gatesburg sand) than for all other treatments. Differences of treatment means of dry weight were not significant.

The large pore spaces in coarse and fine IAR allowed immediate infiltration of irrigation solution, but in treatments 6 (daily irrigation on Gatesburg sand) and 7 (4-hour irrigation on sand) water remained on the surface of the sand until 10 min after irrigation. Since the sand plots remained near saturation throughout the experiment, the oxygenated irrigation solution may not have infiltrated uniformly through these plots to provide the roots with oxygen (9).

The water retention curves (Fig. 2) indicate three relationships. First, the water retention curve for sand shows very little release of water until tensions greater than 15.2 to 22.9 cm (the depth of the bench) are reached. The Gatesburg sand remained saturated throughout the experiment irrespective of irrigation treatments. Steiner (9) pointed out that oxygen could be supplied to plant roots in irrigation water. Oxygen could have limited growth in treatment 6 (Gatesburg sand irrigated daily) to a greater extent than in treatment 7 (Gatesburg sand irrigated every 4-hours) and treatment 8 (Gatesburg sand irrigated constantly) since treatment 6 received oxygenated solution less frequently.

Second, the slope of the curves for fine IAR and coarse IAR indicate a sharp decrease in water content by volume as the tension increases from 0 to 15 cm of water. Thus the depth of the greenhouse bench created sufficient tension to remove substantial amounts of water from both fine IAR and coarse IAR, allowing pore space for oxygen diffusion to roots.

Within a 30-minute period after the irrigation of the Gatesburg sand plots, all of the leachate was collected from that irrigation, whereas the irrigation solution held with less tension in the fine and coarse IAR continued to drain from these plots during the time between irrigations. This suggests that the water in coarse IAR, and to a greater extent in fine IAR, was more available than the water in Gatesburg sand.

Third, water content by volume of fine IAR in the 0 to 15 cm of water tension range was 10 % more than the content of coarse IAR. This increase resulted in a greater hydraulic conductivity in fine IAR. The optimum oxygen-water balance in fine IAR, irrigated constantly or every 4 hr., produced the best Chrysanthemum growth.

LITERATURE CITED

1. BAKER, D.E. 1971. A new approach to soil testing. *Soil Sci.* 112 : 281-291.
2. BOUYOUCOS, G.J. 1928. The hydrometer method for making a very detailed mechanical analysis of soils. *Soil Sci.* 26 : 233-238.
3. COLE, T.E. 1971. Subsurface and trickle irrigation. A survey of potentials and problems. Oak Ridge National Laboratory, Oak Ridge, Tennessee.
4. CUNNINGHAM, R.L., G.W. PETERSEN, R.P. MATELSKI, R.W. RANNEY and E.J. CIOLKOSZ. 1972. Laboratory characterization data and field descriptions of selected Pennyslvania Soils. The Pennsylvania Exp. Sta., University Park, Pa. *Agronomy Series* 25 : 118-119.
5. GOLDBERG, D. and M. SHMELI. 1970. Drip irrigation — a method used under arid and desert conditions of high water and soil salinity. Transactions of the American Society of Agricultural Engineers, Vol. 3, No. 1, pp. 38-41.
6. GROBBELAAR, H.L. 1971. Drip irrigation in South Africa. Trickle irrigation, International Chemical Industries Australia, Melbourne, Australia. pp. 30-32.
7. HANAN, J.J. 1969. The use of inert media in greenhouses. International working group on soilless culture (IWOSG), Proceedings of World Congress, Las Palmas de Gran Canaria. pp. 74-78.
8. KIPLINGER, D.C. 1956. Growing ornamental greenhouse crops in gravel culture. *Ohio Agr. Exp. Sta. Spec. Circ.* 92.
9. STEINER, A.A. 1968. Soilless culture. *Reprint from Proc. 6th Coll. Int. Potash Inst., Florence.* pp. 324-340.