Incorporation of a Hydrophilic Polymer into Annual Landscape Beds[1]

Jennifer L. Boatright[2], Donna E. Balint[2], Wayne A. Mackay[3], and Jayne M. Zajicek[4]
Department of Horticultural Sciences, Texas A&M University
College Station TX 77843

Abstract

The incorporation of a hydrophilic polymer into annual landscape beds was found to buffer temperature changes by as much as 3C (37F) during daylight hours. Under dry conditions, hydrophilic polymer incorporation increased the growth and flowering of petunias by as much as 64% and 75%, respectively. Vinca and marigold flowering did not increase with polymer incorporation. However, in the case of marigolds, the medium rate of polymer incorporation resulted in an average of 40% higher dry weights compared to control plants. Under nonlimiting water conditions, the advantage of using polymers were less pronounced than under dry conditions. In addition, plant growth and flowering were not affected. The findings suggest that drought-sensitive plants such as petunia may benefit from the addition of a hydrophilic polymer in areas receiving little or sporadic rainfall in addition to elevated temperatures.

Hydrophilic polymer used in this study: Cross-linked polyacrylamide—Hydrosource™ (Western Polyacrylamide, Inc., Castle Rock, CO).

Index words: hydrogel, polyacrylamide, water-use, marigold, petunia, vinca, begonia.

Significance to the Nursery Industry

Landscape crops are large consumers of fresh water (3). Information on landscape management practices that are effective in reducing water consumption and decreasing water contamination is severly lacking. Results of this study showed that the incorporation of a hydrophilic polymer benefited drought sensitive plants under dry conditions. However, in conditions when water was plentiful the incorporation of hydrophilic polymer did not provide a benefit to the plants and may possibly have been detrimental to growth and flowering.

Introduction

In many areas of the United States, water availability and/or quality are major problems. Due to the high water and chemical requirements of landscapes, research into management practices that will limit water and chemical use is becoming increasingly important. Enhancing the water holding capacity of the soil with the incorporation of a hydrophilic polymer may be one method to reduce the volume of water used to maintain attractive landscapes.

One method to reduce water consumption in the landscape is the addition of a hydrophilic polymer to the media. Current research on the effects of a polyacrylamide polymer incorporation into potting media found polymers increased water holding capacity of these media (6). In addition to the positive effects on soil characteristics, incorporation of a hydrophilic polymer benefits plant growth and maintenance (6, 7, 9). Some of the most beneficial uses of hydrophilic polymers reported to date include: a) decreased watering amounts (9), b) decreased watering frequencies (6), c) increased time to plant wilt (7), and d) reduced transplant shock (4).

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[2]Graduate Students.
[3]Assistant Professor, El Paso Research Station.
[4]Associate Professor.

Contrary to the positive effects on plant growth and maintenance, there are also reports of no effect and/or negative effects due to the incorporation of hydrophilic polymers. Swietlik (10) found no effect of hydrophilic polymers on trunk-cross-sectional-area, canopy width, or height of newly planted grapefruit trees. Austin and Bondari (1) found detrimental effects of polymer incorporation on field-planted rabbiteye blueberries due to the tight water holding capacity of the polymers inhibiting water uptake by plant roots.

The main objective of these studies was to determine if a hydrogel could significantly reduce the need for irrigation of bedding plants in urban landscapes while still maintaining acceptable plant growth and flowering.

Materials and Methods

Two experiments were conducted at the Texas A&M University turfgrass field laboratory in College Station, TX. The experimental site consisted of sandblasting-quality moderately coarse sand. Approximately, 10.2 cm (4 in) of composted pine bark was incorporated to a depth of 20.3 cm (8 in) based on a recommendation of "Fact Sheet, Annual Flowers in the Home Landscape" (8). For the first experiment, 907.18 g/100 m^2 (2 lb/100 ft^2) of 13N–13P–13K (13N–5.6P–10.8K) (All American Lawn and garden fertilizer, Vigoro Industries Inc., Fairview Heights, IL) was incorporated to a depth of 15.2 cm (6 in).

Plant material consisted of three types of annual bedding plants: petunia (*Petunia parviflora* cv. Lilac Madness), marigold (*Tagetes micrantha* cv. Safari Orange), and vinca (*Catharanthus roseus* cv. Tropicana Bright Eye). These bedding plants were chosen to provide a range of drought tolerance, with vinca being highly drought tolerant, marigold being moderately drought tolerant, and petunia being sensitive to drought (11).

Treatment rates of a cross-linked polyacrylamide hydrogel (Hydrosource™, Western Polyacrylamide Inc., Castle Rock, CO) included: 0, 122, 244, 366, or 488 g/m^2 (0, 25, 50, 75, or 100 lb/1000 ft^2). Each treatment was replicated four times with ten plants of each species planted in each replication (plot) for a total of forty plants per species per treatment.

Each plot was 1.0 m (3.33 ft) by 1.22 m (4.0 ft). The plots were outlined with metal edging to visually and mechanically separate each individual plot. In addition, a 45.7 cm (1.5 ft) space was left between each plot to further insure plot separation. Sand was removed from individual plots to a depth of 20.3 cm (8 in), polymers were mixed in thoroughly, the mixture was returned to plots, and the beds were left to absorb rain water (approximately 11.4 cm) for two weeks. On May 16, 1993, the beds were covered with weed barrier (Weed Barrier®, Dewitt Co., Sikeston, MI) to reduce competition from weeds and evaporation of water. Slits were marked and cut in the weed barrier for planting of the annuals on 20.3 cm (8 in) centers. Plants were transplanted from 606 jumbo packs (cell size: 2.9 cm × 2.2 cm) on May 20, 1993. A 1 cm (0.5 inch) layer of pine bark nuggets, ranging in size from 2.5 cm^2 (1 in^2) to 7.6 cm^2 (3 in^2), with a thickness of approximately 0.4 cm (0.25 in) to 2.5 cm (1 in) were spread over the weed barrier, a common landscape practice.

A weather station at the site recorded relevant weather data daily including precipitation. Number of flowers for each species was recorded weekly. Soil temperatures at the soil surface and at a depth of 10.2 cm (4 in) were averaged every fifteen minutes using soil thermocouples and 21X dataloggers (Campbell Scientific Inc., Logan, UT). Due to lack of equipment, soil temperatures were only measured on replications for the 366 g/m^2 treatment and the control. Soil cores, 15.4 cm (6 in) deep, were taken weekly on each replication for each treatment to measure soil moisture content. These cores were weighed, oven dried at 110C (230F) for 18 hours, and reweighed. Percent moisture was calculated from these weights. Plants were harvested on August 27, 1993, and oven dried for four days at 60C (140F) for dry weights.

A second experiment initiated in August of 1994, investigated the effect of the incorporation of nitrogen in addition to polymer incorporation. Petunia (*Petunia parviflora* cv. Midnight Madness) and begonia (*Begoniacea semperflorens* cv. Pink Encore) were tested. Petunia was selected for the experiment due to the plant's sensitivity to drought stress and nitrogen deficiencies. Begonia was also used because of its sensitivity to drought stress (11).

Treatments included fertilizer rates of 0 or 2.0 kg/1000 m^2 (0.41 lb/1000 ft^2) of ammonium sulfate plus 1.9 kg/1000m^2 (0.38 lb/1000 ft^2) of calcium nitrate and hydrophilic polymer rates of 0 or 366 g/m^2 (75 lb/1000 ft^2) for a total of four treatments. Each treatment was replicated six times with ten plants of each species planted in each replication (plot). The 366 g/m^2 rate was selected, as it has been reported as a reasonable quantity of polymer to produce a detectable difference in plant growth (12).

Plants were transplanted on August 3, 1994. Precipitation, flower number, percent soil moisture, and dry weights at harvest were collected in the same manner as field experiment one. Soil temperatures were also measured at a depth of 10.2 cm (4 in) on four replications for all treatments. Plants were harvested on September 30, 1994, and oven dried at 60C (140F) for four days for dry weights.

Data for both studies were analyzed using 1992 Statistical Analysis System's (SAS Institute, Cary, NC) statistical package. As the treatments in the first experiment were quantitative, regression analysis fitting a linear response function was performed. In the second experiment, analysis of variance was performed on the 2 × 2 factorial design.

Results and Discussion

Experiment 1. Soil measurements. Percent soil moisture was calculated from soil cores taken five times over a 10 week period. During the 10-week period, there was little rainfall and no supplemental irrigation. Although not found to be statistically significant, soil moisture content of the soil did increase with the addition of the polymer (Table 1). On week four the 488 g/m^2 and 244 g/m^2 treatments had a soil moisture of 25.5% and 23%, respectively compared to the control of 18%. On week six, the 244 g/m^2 still retained 16.5% soil moisture, compared to 14% in the 488 g/m^2 and 7% in the control. By the eighth week all treatments had dropped to approximately 6% soil moisture.

Soil temperatures were found to be significantly different between treatments at both the surface and at the 10.2 cm (4 in) depth (Fig. 1). On June 11 (a representative day) temperatures on the surface of the control were the highest, reaching an approximate temperature of 39C (102F) at 1400 h compared to the treated surface temperature of approximately 33 to 36C (91 to 97F). The control at a depth of 10.2 cm (4 in) consistently remained approximately 2 to 6C higher than the 366 g/m^2 treatment during daylight hours. In addition, the diurnal temperature curve of the polymer-treated plots is less severe than the control plots (Fig. 1). Soil temperature is one of the major factors affecting plant growth (5), although research on the effect of hydrophilic polymers on soil temperatures has been limited to date.

Plant measurements. Petunia plants had significantly more flowers at the high polymer rates compared to the controls (Fig. 2 and Table 2). Plants in polymer incorporated plots of

Table 1. Mean and standard error values of % soil moisture values of the control and polymer-treated plots over a ten week period.

	Soil moisture (%)									
	Week 1		Week 4		Week 6		Week 8		Week 10	
Treatment	**mean**	**SE**	**mean**	**SE**	**mean**	**SE**	**mean**	**SE**	**mean**	**SE**
Control	34.5	4.5	18.5	0.5	7.0	2.0	6.0	1.0	4.0	0.0
122 g/m^2	35.5	1.5	17.5	0.5	9.5	3.5	5.5	0.5	4.0	0.0
244 g/m^2	42.5	2.5	23.0	1.0	14.0	0.0	5.0	0.0	4.5	0.5
366 g/m^2	51.5	1.5	26.0	0.0	15.0	2.0	6.0	0.0	3.5	0.5
488 g/m^2	47.5	6.5	25.5	0.5	16.5	1.5	6.0	0.0	3.5	0.5
Significance[z]	NS		NS		*		NS		NS	

[z]NS, *, **, *** Nonsignificant or significant at 0.05, 0.01, 0.001 level, respectively

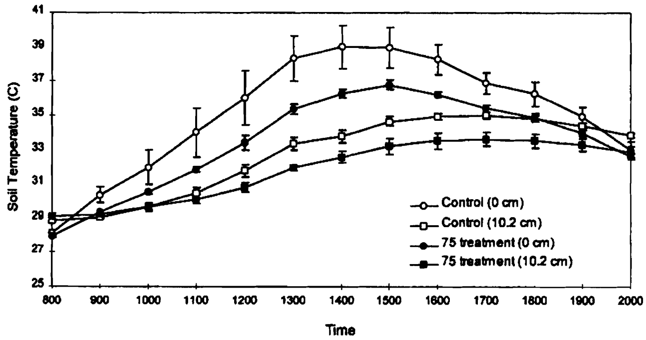

Fig. 1. **Soil temperatures on June 11, 1993 for four treatments of hydrogel incorporation. Vertical bars represent +/– SE; bars smaller than symbols are not shown. Each point is the mean of four temperature samples. Statistical significance of 0.05 was detected.**

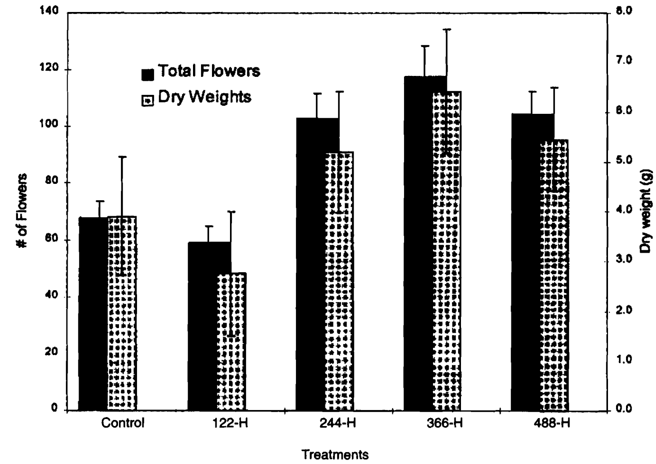

Fig. 2. **Total petunia flowers and dry weights for six treatments of hydrogel incorporation. Control (C), hydrophilic polymer application rates of 25, 50, 75, or 100 lb/1000 sq ft (25-H, 50-H, 75-H, and 100-H). Vertical bars represent +/– SE; each bar represents the mean of 40 plants.**

Table 2. **Regression analysis performed to determine the relationships between the flower count and dry weight of petunia, marigold, and vinca plants grown in media with various levels of polymer addition (0, 122, 244, 366, and 488 g/m²).**

	Flower count					
	Petunia		Vinca		Marigold	
Treatment	mean	SE	mean	SE	mean	SE
Control	65.5	12.3	94.4	23.2	13.2	6.9
122 g/m²	70.9	27.7	87.3	20.1	10.9	2.7
244 g/m²	112.5	16.9	95.9	5.8	11.5	2.4
366 g/m²	125.2	48.6	125.4	15.5	15.0	3.5
488 g/m²	121.6	14.4	105.2	29.0	11.8	3.1
Significance[z]	***		NS		NS	
	Dry weight					
Control	3.4	0.4	8.5	3.7	7.7	1.7
122 g/m²	3.0	0.8	6.9	0.7	7.3	0.5
244 g/m²	5.7	1.1	7.6	0.9	9.6	2.3
366 g/m²	6.6	2.9	7.5	1.0	11.0	0.9
488 g/m²	6.1	1.5	7.1	1.4	8.5	2.1
Significance[z]	*		NS		NS	

[z]NS, *, **, *** Nonsignificant or significant at 0.05, 0.01, 0.001 level, respectively.

244, 366, and 488 g/m² had approximately 63% more flowers than those in the 122 g/m² treatment and the control. This trend was also reflected in dry weights with plants in plots containing the three highest rates of polymer incorporation having approximately twice the plant growth as the lowest treatment and the control.

Vinca flowering followed a similar response pattern to polymer application as petunia flowering. For example, the 366 g/m² averaged 125 total flowers per plant compared to the control averaging 94 flowers per plant. However, although 366 g/m² and 488 g/m² treatments had greater flower counts than all other treatments, it not found to be statistically significant (Table 2). Dry weights for vinca were somewhat variable compared to other results. Increased polymer concentration did not result in greater dry weight values and were even less than the control plants dry weight.

Marigold flowering and dry weight were greatest at the 366 g/m² treatment. No other trend was detected for these plants (Table 2). This maybe the optimum concentration to benefit these moderately drought tolerant plants.

Experiment 2. Soil measurements. In the second experiment, soil moisture percent was calculated from soil cores taken over a six week period (Table 3). Due to extremely wet conditions, data was collected for only four of the six weeks.

Table 3. **Mean and standard error values of % soil moisture values of plots containing various soil amendments on four sampling days. Treatments included polymer incorporation of 366 g/m² into soils with and without a nitrogen application (2.0 kg/1000 m²).**

	Soil moisture (%)							
	Aug. 19		Aug. 31		Sept. 14		Sept. 21	
Treatment	mean	SE	mean	SE	mean	SE	mean	SE
Soils without Polymer (Control and Nitrogen)	29.4	3.5	21.5	1.7	28.3	1.4	25.3	1.4
Soils with Polymer (Polymer and Polymer & Nitrogen)	31.6	2.4	29.6	1.2	34.0	1.0	30.6	1.0
Significance[z]	NS		**		**		*	

[z]NS, *, **, *** Nonsignificant or significant at 0.05, 0.01, 0.001 level, respectively.

Table 4. **Regression analysis performed to determine the benefit of polymer incorporation (366 g/m²) along with nitrogen application (2.0 kg/1000 m²) in terms of increased flower count and dry weight of petunia and petunia plants. Poor growth and flowering of plants were most likely due to excessive rainfall that occurred during this experiment.**

	Petunia				Begonia			
	Flower ct.		Dry wt.		Flower ct.		Dry wt.	
Treatment	mean	SE	mean	SE	mean	SE	mean	SE
Control	6.3	8.4	0.5	0.1	0.3	0.7	3.4	3.3
Nitrogen	12.8	11.1	1.2	0.9	1.9	2.4	0.5	0.5
Polymer	9.2	11.8	0.5	0.3	1.1	2.1	0.7	0.5
Nitrogen + polymer	10.5	12.3	0.9	0.5	1.6	2.5	1.7	2.2
Significance[z]	NS		NS		NS		NS	

[z]NS, *, **, *** Nonsignificant or significant at 0.05, 0.01, 0.001 level, respectively.

For the last three measurements, the polymer treated plots (both with and without nitrogen) had mean soil moisture percentage values of 30, 34, and 31 while the polymer untreated plots (with and without nitrogen addition) had values of 22, 28, and 25. Even under wet conditions, the addition of polymer increased soil moisture significantly when compared to soils without the polymers.

Unusually high amounts of rainfall for the months of August and September occurred during this experiment. Although the sandy soils of the experimental site allowed for high drainage, 8 to 12 inches below this sandy soil is a clay pan which prevents the drainage of excess water. Poor growth and flowering of plants regardless of treatment resulted from excessive water levels in the experimental plots (Table 4).

Nitrogen application affected plant growth; however, there were no significant effects due to polymer incorporation (Table 4). The nitrogen treatments resulted in a two-fold increase compared to plots without nitrogen.

Incorporation of the hydrophilic polymer did not positively affect the plant parameters for this experiment. The large amount of periodic rainfall provided an adequate amount of water for plants without polymer incorporation, and any additional water stored by the polymer was not beneficial. In fact, additional water stored in the polymer treated plots may have had a negative effect on plant growth due to the possible anaerobic conditions derived from the excessive amount of water. Flannery and Busscher (6) reported similar results on azalea, with reduced plant growth due to the incorporation of hydrophilic polymers which they also attributed to decreased aeration.

In this research, the incorporation of a hydrophilic polymer into sandy soil increased the soil temperature buffering capacity, resulting in less diurnal flucuations than in untreated plots. Soil moisture retention times were also found to be extended with the addition of the polymer. Under dry conditions the incorporation of a hydrophilic polymer increased growth and flowering of bedding plants that were sensitive to drought. These results are similar to those of Bearce and McCollum (2) who reported increased plant height, dry weights, and number of flowers per plot of chrysanthemums with the incorporation of hydrophilic polymers. Although similar patterns were observed with the flowering of vinca plants, effects were not as pronounced possibly due to the drought tolerance of vinca. Marigold plants, which are also more drought tolerant than petunia plants, were even less affected by polymer incorporation. Under wet soil conditions, the hydrophilic polymer did not prove to be beneficial and was actually found to be detrimental to the growth and flowering of bedding plants.

In conclusion, the data indicates that hydrophilic polymers may be beneficial to drought sensitive bedding plants under dry conditions. Areas where water and labor are factors, such as highway medians or in larger landscapes, better plant growth may be supported with the incorporation of hydrophilic polymers.

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