

The Effects of Soil Incorporated PEG-8000 on Stem Elongation and Whole Plant Photosynthesis and Respiration of Marigold (*Tagetes patula*)

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Nature of Work: Seedling quality in bedding plants is an important selling factor, since seedling 'plugs' are sold to other growers who demand high quality plants. Height control is one important aspect of quality (5). Hypocotyl height of seedlings is particularly difficult to control, especially in plants such as marigolds. This is because hypocotyl elongation occurs early in seedling development, before standard height control measures are taken. For example, chemical plant growth retardants are typically not applied until the first true leaves have emerged. At that point, the hypocotyl has completely elongated, so it is too late to control hypocotyl height. This is a particularly important problem in species like marigold, where hypocotyl length accounts for much of the overall seedling height.

One option for controlling height and hypocotyl elongation of seedlings is to reduce the water available in the growing medium. Drought stress has been used to control growth of annual salvia and broccoli transplants (2, 3). One disadvantage of drought stress is that it can also cause plant damage or even plant death. However, height of annual salvia seedlings was controlled using drought stress (1). This controlled stress involved applying the osmotic compound polyethylene glycol (PEG-8000) to growing media (1). At low rates, PEG-8000 did not cause plant damage (1).

There were two main objectives of this experiment. First, we determined whether PEG-8000 also reduces growth and hypocotyl elongation of marigold seedlings. Second, since photosynthesis often decreases when plants are drought stressed, whole plant photosynthesis and respiration were measured.

Polyethylene glycol 8000 was mixed with water and added to a commercial peat-based growing medium (Germinating Mix, Fafard, Anderson, S.C.) at the following concentrations: 0, 0.125, 0.167, 0.25, 0.35, or 0.417 lb-gal⁻¹ (0, 0.015, 0.02, 0.03, 0.042, or 0.05 kg.L⁻¹). Each PEG-8000 and growing medium combination was then shaken vigorously in a large plastic container for ten minutes to produce a homogenous mix. Treated growing medium was placed in 6x6 cell sections cut from 288-trays (cell volume = 0.287 oz (8.5 mL)).

Two marigold 'Boy Orange' seeds/cell were planted in each tray on June 6, 2003. Marigold seeds were germinated in a growth chamber at 68 °F (20 °C). While in the growth chamber, plants were misted overhead by hand as needed to maintain a constant water content. After germination, seedlings were grown on a mist bench in a glass greenhouse and irrigated approximately 20 s every 30 min from 6:00 am until 6:00 pm (EST). Experimental unit weight

was recorded twice daily and plants were removed from the mist bench when necessary to maintain constant water contents ($91 \text{ g} \pm 11 \text{ g}$). This also prevented leaching of PEG-8000 from the growing medium, which would result in loss of PEG and thus change treatment levels.

The smallest seedling was removed from cells containing more than one plant 22 days after seeding. All seedlings were fertilized once weekly at 200 ppm ($\text{mg}\cdot\text{L}^{-1}$) N with a 20N:8.7P:16.6K fertilizer (20-20-20 General Purpose, Scotts Company, Marysville, Ohio) when the first true leaves were visible (23 days after seeding), then at least once/week afterwards.

Data collected include the height at germination (when cotyledons were perpendicular to the hypocotyl) and 18, 32, and 42 days after seeding. Whole plant carbon exchange rates of four replications were measured in light (photosynthesis) and dark (respiration) were measured at the termination of the experiment (42 days after seeding). Carbon exchange was measured at 20 min intervals in multiple acrylic chambers as described by van Iersel and Bugbee (6). To correct for differences in plant size among treatments, photosynthesis was divided by leaf area and respiration was corrected for differences in shoot dry weight.

The experimental design was a randomized complete block design with six blocks/treatment and 16 subsamples/treatment. Data were analyzed by linear and quadratic regression analysis using general linear models in statistical analysis systems (Statistical Analysis Systems, Cary, NC).

Results and Discussion: Marigold seedlings were 13% shorter at emergence in the highest PEG-8000 concentration than in the control treatment (Fig. 1). The highest rate reduced heights 33%, 38%, and 38% compared to controls, 18, 32, or 42 days after seeding, respectively (Fig. 1). Also, 18 days after seeding, marigolds treated with PEG-8000 had shorter hypocotyls than control plants (Fig. 1). This response is similar to the growth reduction observed for annual salvia (1). In that previous experiment, growth reduction was correlated with reduced leaf water potential. However, reducing the available water in the substrate, as was done in these experiments, typically also affects physiological factors other than just the leaf water potential.

In this case, whole plant photosynthesis decreased with increasing PEG-8000 rate (Fig. 2). When photosynthesis was corrected for differences in plant size, photosynthesis per unit leaf area still decreased with increasing concentrations of PEG-8000 in the growing medium (Fig. 2). Whole plant respiration rates also decreased with increasing PEG concentrations; however, respiration per unit shoot dry weight increased with increasing PEG-8000 (Fig. 2). Drought-stressed plants often photosynthesize less (4), and this response has been observed in other horticultural plants (2). So, the observed height reduction was also correlated with reduced whole plant photosynthesis. This is not surprising, since photosynthesis provides the carbohydrates needed for growth.

Significance to Industry: Quality is a major factor determining the marketability of annual bedding plant seedlings. Compact seedlings with short hypocotyls would be considered high quality because they are cheaper to ship, easier to manage in greenhouses, and more aesthetically pleasing. Incorporating the osmotic compound polyethylene glycol 8000 (PEG-8000) into soil reduces growth and hypocotyl height of marigolds by creating a controlled drought stress. Marigolds grown with 0-0.25 lb·gal⁻¹ PEG-8000 in the growing medium were high quality, but did photosynthesize less than plants grown normally. Further research should determine the effects of PEG-8000 on fertilization and irrigation schedules, cost management, and growth after transplant.

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Figure 1: The effects of the addition of PEG-8000 to the growing medium on height of marigold seedlings at emergence, and at different times during seedling production. Data are the mean of six replications \pm standard error.

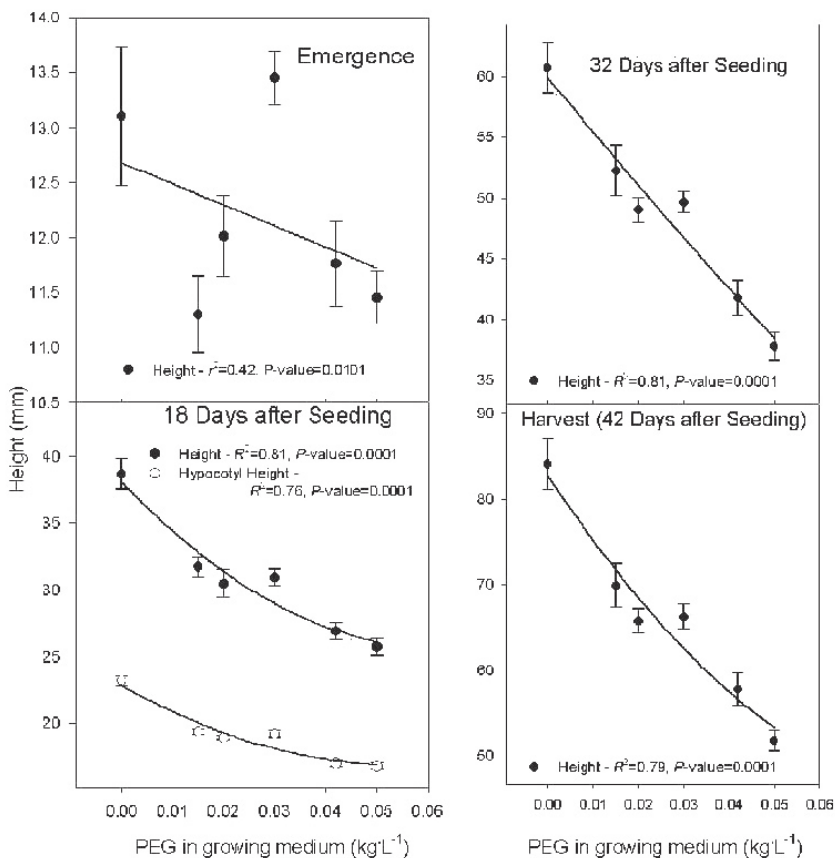


Figure 2: The effects of the addition of PEG-8000 to the growing medium on photosynthesis and respiration of marigolds. The upper two panels represent whole plant photosynthesis (left) and respiration (right). The lower two panels represent photosynthesis (left) and respiration (right), corrected for leaf area or shoot dry weight for photosynthesis and respiration, respectively. Data are the mean of four replications \pm standard error.

