

# Efficacy of a Hydrophilic Polymer Declines with Time in Greenhouse Experiments

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**Abstract.** The effect of a hydrophilic polymer (Broadleaf P4®; HP) on growth of cucumber seedlings (*Cucumis sativus* L.) was investigated. Furthermore, the efficiency of HP to absorb water over a period of time was studied. Predetermined amounts of HP (0.0%, 0.1%, 0.2%, 0.3%, and 0.4% dry-weight basis) were mixed with moderately calcareous sandy loam soil in pots. At the end of the first experiment (42 days), the growth of the seedlings was recorded, as well as the maximum soil water-holding capacity (WHC). The same pots were left for a drying period ranging from 2 to 5 months and then used for another four successive experiments. Soil WHC increased significantly with increasing level of HP, but decreased after each experiment. After five experiments, the WHC had decreased 17.3% and 27.8% where HP was added at the rate of 0.1% and 0.4%, respectively. The bulk density of soils decreased significantly with addition of HP and had increased after five growing experiments at each HP rate. Cucumber seedling growth was stimulated by addition of the polymer. The greatest vegetative growth, expressed as leaf area and shoot fresh and dry weights, was observed at 0.3% HP in the first and second experiment, but at 0.4% in the third and fourth.

Research on hydrophilic polymers (HP) as soil amendments has been intensified in the last decade. Water-absorbing synthetic polymers may improve the properties of light-textured soils and therefore stimulate plant growth. Addition of HP increases water-holding capacity (WHC) and reduces evaporation losses and can significantly increase water use efficiency (Al-Omran et al., 1987; Johnson, 1984). This improved water balance has stimulated seed germination and seedling growth (Al-Harbi et al., 1994; Janet and Hensley, 1986; Save et al., 1995). However, large-scale use of HP is still limited, especially in the field and in greenhouses. Salinity of soil and irrigation water, which is further enhanced by addition of fertilizers, reduces the hydration of HP (James and Richards, 1986; Lamont and Connell, 1987; Wang and Gregg, 1990). An-

other limiting factor is the unknown duration of HP's beneficial effect in absorbing water. Little work has been done to measure the long-term breakdown rate of HP, which depends upon the rate and depth of application, weathering of soil, tillage operations, and many other factors (Seybold, 1994). Orzolek (1993) reported that degradation of HP appears to result from microorganisms, modification of physical structure, and chemical decomposition; as a result, HP lose 10% to 15% of their activity each year.

This study was designed to investigate the effect of HP, applied at several rates over a long period of time, on the growth of cucumber seedlings grown in pots under greenhouse conditions, and to measure its breakdown rate.

## Materials and Methods

Five successive pot experiments were carried out over a period of 2 years (22 Apr. 1994 to 17 Apr. 1996). A bulk surface sample (25 cm) from a calcareous sandy loam soil (Typic Torripsamments) was collected at the Agricultural Experimental Station of King Saud Univ. at Deirab. The soil was air-dried and passed through a 2-mm sieve. Soil properties, determined using standard procedures, were as follows: organic matter (0.75%), CaCO<sub>3</sub> (28%), pH (7.8), EC<sub>e</sub> (0.76 dS·m<sup>-1</sup>), sodium adsorption ratio (8.1), clay (11%), silt (12%), and sand (77%).

The HP (Broadleaf P4®; Agricultural Polymers Ltd., Gloucester, U.K.) used in this study is an insoluble, granular Na-polyacrylamide material. The required weights of polymer were hand-mixed with dried soil to give five concentrations on a dry-weight basis: 0 (control), 0.1%, 0.2%, 0.3%, and 0.4%. The treatments were replicated four times in a completely randomized design. Plastic pots 20 cm wide and 22 cm deep of 7-L volume were filled with 7 kg of treated soil. The pots were placed in a greenhouse at temperatures of 25 °C day/18 °C night.

Initially, all the pots were irrigated with predetermined amounts of municipal tap water (EC = 0.38 dS·m<sup>-1</sup>) to bring the moisture content of the soils to field capacity. Five cucumber seeds were sown in each pot. The seedlings were thinned to one per pot at the second-leaf stage; thereafter, the pots were irrigated once a week with irrigation water containing dilute but well-balanced McLean and Gilbert nutrient solution-1, which is very low in divalent cations (Hewitt, 1966). Field capacity of the soil was determined at the beginning of each experiment using the small-core method of Cassel and Nielsen (1986). The moisture lost was calculated by weighing the control (untreated soil) and this amount of water was added to each pot.

In the first experiment, the seeds were sown on 22 Apr. (0 day after mixing) and the experiment was ended on 7 June 1994. Four other experiments with similar growth conditions were carried out in the same pots, which were allowed to dry 2 to 5 months between experiments. The duration for the subsequent experiments were 21 Nov. 1994 to 8 Jan. 1995 (213 d after mixing); 1 Apr. to 3 May 1995 (344 d after mixing); 15 Oct. to 26 Nov. 1995 (541 d after mixing); and 5 Mar. to 17 Apr. 1996 (683 d after mixing). Leaf area and shoot fresh and dry weights were determined at the end of each growing period. The data were analyzed by analysis of variance, and least significant differences were calculated for each experiment.

The WHC was determined at the beginning of each experiment, prior to sowing the seeds, by using plastic rings (40-mm diameter). The rings were filled with soil (=25 g) to a uniform compaction and half-immersed in deionized water for 24 h to obtain maximum saturation. Excess water was drained by placing the covered rings over glass funnels. After half an hour, the soils were weighed and mois-

Table 1. Effect of addition of hydrophilic polymer (HP) on bulk density of a calcareous soil at the beginning and at the end of Expts. 1–5.

HP (%)	Bulk density (g·cm <sup>-3</sup> )	
	Initial	Final
0.0 (Control)	1.46	1.46
0.1	1.36	1.35
0.2	1.18	1.23
0.3	1.00	1.12*
0.4	0.90	1.07*
LSD <sub>0.05</sub>	0.21	0.04

\*Significantly different from initial value at  $P \leq 0.05$  by standard  $t$  test.

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