THE EFFECT OF SOIL ADDITIONS OF HEXADECANOL AND ROHAGIT ON SOIL EVAPORATION AND THE TRANSPIRATION AND GROWTH OF BEAN PLANTS

By

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Experiments were carried out on the effects of hexadecanol, a long-chain alcohol, and Rohagit, a polyelectrolytic soil conditioner, on evaporation from a loess soil, and on transpiration and growth of bean plants. Applications of 5% hexadecanol and 1% Rohagit decreased evaporation from bare soil. The addition of hexadecanol to the soil had an unfavorable effect on the percentage of available water. Plant growth was retarded strongly by this substance and the rate of transpiration was increased up to three times by 5% hexadecanol. Rohagit, when applied at rates between 0.02% and 0.2%, had a favorable effect on soil structure, and resulted in increased root development and a slightly more efficient use of available water.

INTRODUCTION

Controversial results were published recently on the effects of long-chain alcohols in the rooting medium on transpiration and plant growth. Roberts (12) claimed that hexadecanol lowered the transpiration rate of corn by 40% while the yields of treated plants were not affected. Other investigators found a reduction of plant growth following hexadecanol treatments (2, 8, 9, 13).

Synthetic soil conditioners were found to increase the available water held in the soil (5). In later works, however, a lowering of the field capacity by these soil conditioners is reported (1, 4).

In this work the effects of Rohagit, a polyelectrolytic soil conditioner, and of hexadecanol, a long-chain alcohol, were tested on the water retention curve of a loess soil. In addition, their effects on the rate of evaporation from bare soil, and on the transpiration of bean plants grown under different irrigation regimes were studied.

MATERIALS AND METHODS

A loess soil from Gilat in the northern Negev was used in all the experiments. Its mechanical composition was 19.5% clay, 30.9% silt, 47% fine sand and 2.6% coarse sand. Its pH was 8.1 and the soil contained 19.7% $CaCo_3$ and 0.035% total nitrogen.

The greenhouse experiment was carried out at a mean daily temperature range

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of 12°–26°C and a relative humidity between 40 and 80%. The outdoor experiment was carried out in a wire screen house at temperatures of 24°–32°C and a relative humidity between 30 and 90%.

The substances applied were hexadecanol*, mixed with dry-sieved (2 mm) soil at the rates of 0.1%, 1% and 5% by weight; and Rohagit 7678**, mixed with sieved soil at 10% soil moisture at the rates of 0.02%, 0.2% and 1% for the greenhouse experiment, and 0.01%, 0.02%, 0.04% and 0.1% for the outdoor experiment. The soil from the 0.2% treatment of the greenhouse experiment was used as an additional treatment in the outdoor experiment.

The test plants were beans, *Phaseolus vulgaris* L. var. Brittle Wax, grown in pots containing 1 kg soil. The soil treatments were tested under the following four moisture regimes, which were imposed at the time of expansion of the first trifoliated leaf and were continued until the beginning of the podding stage: irrigation at 8% (wilting point), 11%, 14% and 20% soil moisture by weight. All treatments were replicated six times in a split plot design with irrigation representing the main plots and soil treatments the subplots. The amount of water loss was established by frequent weighings of the pots, which were watered to pot capacity (28% soil moisture). The pots were covered with black polyethylene to minimize evaporation from the soil. Leaf areas were determined at ten-day intervals by multiplying the product of length and breadth of each by a factor of 0.59, which had been established in a preliminary trial. At the end of the experimental period fresh and dry weights of plant tops were determined. In the outdoor experiment, roots were weighed as well.

Wet sieving tests (14) were carried out on the soil from pots from one replicate of the outdoor experiment.

The moisture retention curves of treated and untreated soil were determined according to standard procedure (11).

Evaporation from bare soil was measured under the above mentioned greenhouse conditions in an additional pot experiment with six replications. The pots were irrigated to pot capacity and left uncovered. Their soil moisture content was determined by weighing several times during two drying cycles.

RESULTS AND CONCLUSIONS

The moisture retention curves of Gilat soil treated with different concentrations of hexadecanol are shown in Fig. 1. At the lower tensions the treated soil contained less moisture than the control, whereas at the higher tensions the opposite effect can be discerned in the 1% and 5% concentrations. The percentage of available moisture (the moisture content between 0.5 atm and 15 atm tension) was 9% in the untreated soil, 7% in the 0.1% hexadecanol-treated soil and only 4.5% in the soil treated with the two higher concentrations of hexadecanol. Rohagit at 0.02% and 0.2% showed

* Supplied under the trade name "Aquasave" by the Arista Co., N.Y.

** A product of Rohm and Haas Co., Germany. Its chemical composition is copolymeric Ca and Na salts of metacrylic acid.

a similar trend, but the results were not significant. The soil treated with 1% Rohagit did not give consistent results, owing to difficulties in obtaining complete saturation of the waterproofed aggregates.

The results of the measurements of evaporation from bare soil are given in Fig. 2.

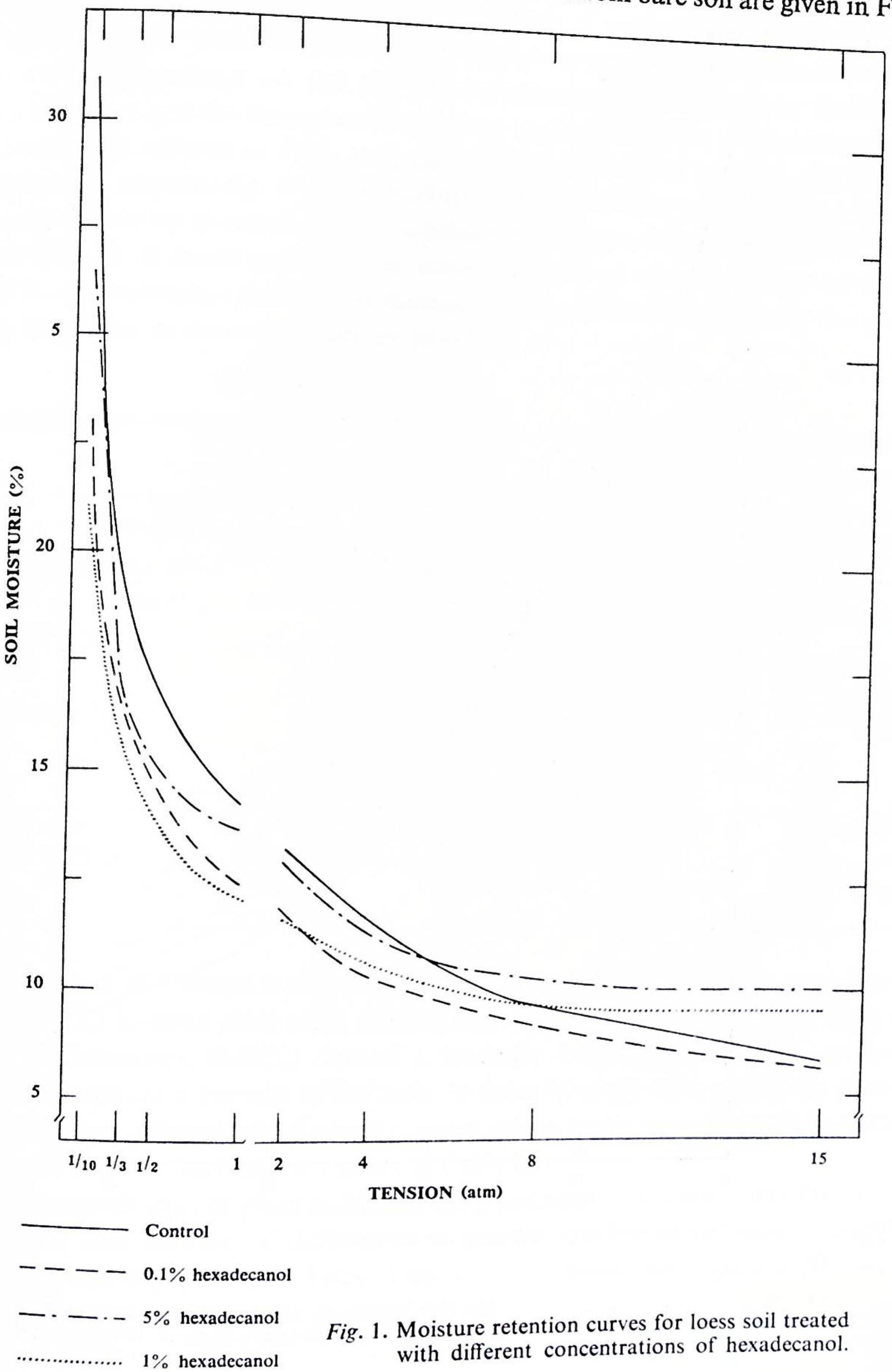

Fig. 1. Moisture retention curves for loess soil treated with different concentrations of hexadecanol.

The two higher rates of both substances reduced water loss by evaporation, as has been found also by other workers (2, 7). It must be emphasized, however, that the greater amount of water retained in the soil this way does not necessarily decrease the water requirements of the plants, since this excess of water is retained in the soil more strongly (see Fig. 1).

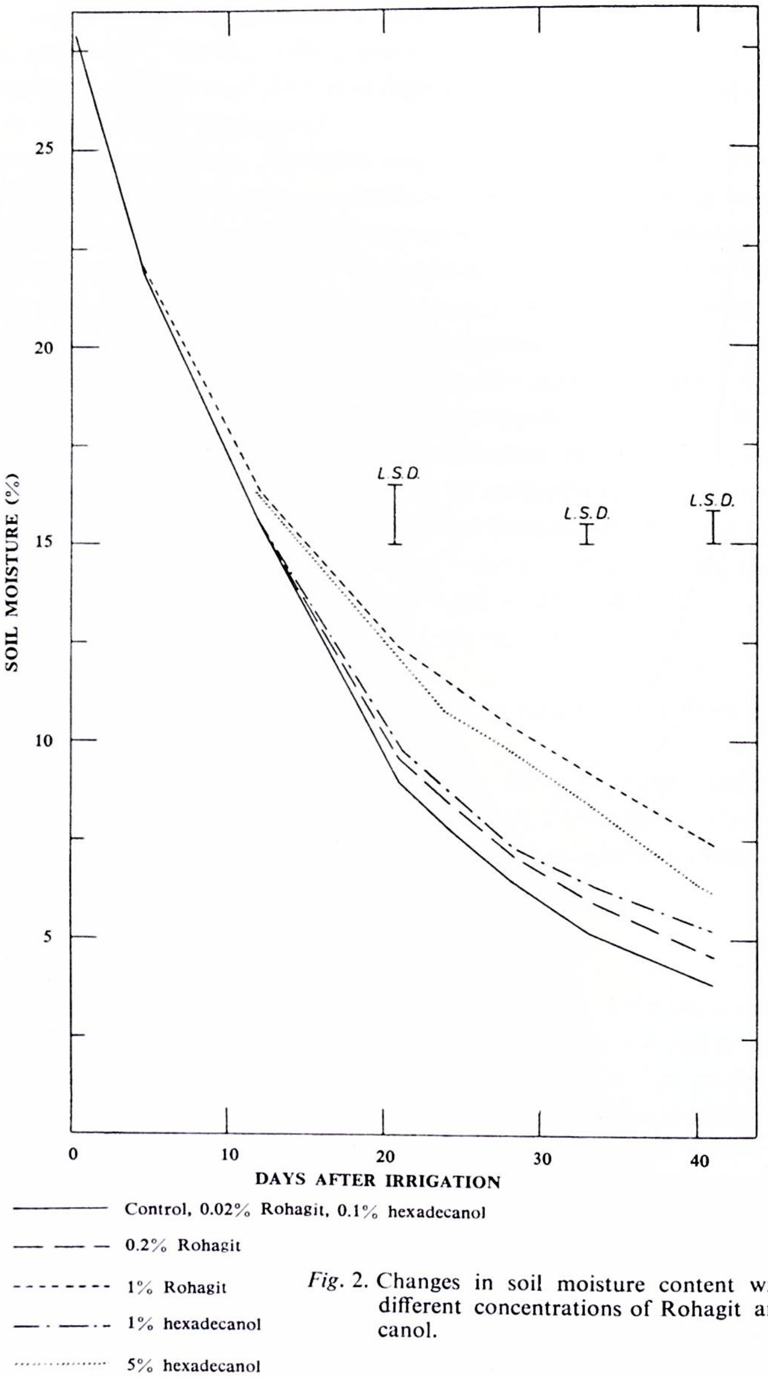

Fig. 2. Changes in soil moisture content with time at different concentrations of Rohagit and hexadecanol.

The effects of hexadecanol on plant growth and transpiration are summarized in Table 1. Only the averages of the figures for all the moisture regimes are presented, since no significant interactions between irrigation and soil treatments were found. The most pronounced effect of hexadecanol obtained in this experiment was the retardation of plant growth, even at the lowest rate of application. The total amount of water used per plant decreased with increasing rates of hexadecanol, but the production of dry matter per unit of water transpired was also reduced by the hexadecanol treatment and the transpiration rate was increased. As the yields of the wettest treatment were reduced to 57%, 16% and 15% of the control by 0.1%, 1% and 5% hexadecanol, respectively, it seems unlikely that this adverse effect on plant growth was caused only by the decrease in available soil moisture as shown by the retention curves (Fig. 1). It seems probable that there was a direct toxicity, which was caused either by the substance itself, by its decomposition products taken up by the plants or by impurities in the commercial preparation.

TABLE 1

THE EFFECTS OF HEXADECANOL AND ROHAGIT IN THE SOIL ON THE GROWTH AND TRANSPIRATION OF BEAN PLANTS

(Data are means of four irrigation treatments)

Treatment	*Dry weight of plant shoots* (g per plant)	*Transpiration per unit of leaf area 30–40 days after emergence* (mg/cm²/day)	*Dry matter produced per unit of water transpired* (mg/g)
Control	3.51	69	3.56
Hexadecanol 0.1%	2.09	81	3.10
1%	0.65	136	1.58
5%	0.55	199	1.56
S. E.	0.09	9	0.09
Rohagit 0.02%	3.82	61	3.73
0.2%	3.58	66	3.61
1%	2.94	67	3.71
S. E.	0.14	3	0.09

The effect of Rohagit is also presented in Table 1. The highest concentration of Rohagit (1%) lowered plant yield significantly compared with the control, while the lowest concentration (0.02%) showed a tendency toward higher yields and lower rates of transpiration per unit of leaf area. In order to verify these results the outdoor experiment was initiated with Rohagit concentrations in this lower range (0.01–0.1%); the results of this experiment are given in Table 2.

The general level of plant yields in this experiment was much lower than in the greenhouse trial because of differences in growing conditions and nutrient supply. The 0.04% and 0.1% levels of Rohagit showed a small increase in plant yields, which was due mainly to better root growth, and was not accompanied by an increase in water use efficiency. While the rates of Rohagit above 0.04% showed a significant

TABLE 2

THE EFFECT OF CONCENTRATION OF ROHAGIT ON THE GROWTH AND TRANSPIRATION OF BEAN PLANTS GROWN OUTDOORS

(Averaged over four irrigation treatments)

Treatment	*Dry matter* (g)			*Final leaf area* (cm^2)	*Total water transpired* (g)	*Dry matter produced per unit of water transpired* (mg/g)	*Water stable aggregates* > 0.25 mm (%)
	Shoots	Roots	Total				
Control	1.11	.31	1.42	287	735	1.83	5.91
Rohagit 0.01%	1.12	.43	1.55	250	1052	1.51	8.27
0.02%	1.00	.38	1.38	211	886	1.58	6.79
0.04%	1.15	.52	1.67	258	957	1.85	16.58
0.1 %	1.10	.51	1.62	236	879	1.76	22.67
0.2%*	1.76	.92	2.78	315	1275	2.17	20.12
S.E.	0.14	.06	.12	18	220	.11	1.83

* The soil for this treatment was prepared two years prior to this experiment and beans had been grown in it during a previous experiment.

increase in water stable aggregates, only the 0.2% treatment showed an appreciable increase in plant yield and water use efficiency, as seen by the amount of dry matter produced per unit of water transpired. The effect of the 0.2% concentration on yield could be explained by the fact that the soil had been prepared previously and had a different nutritional status. On the other hand, it is possible that the Rohagit achieved higher effectiveness after passing through more wetting and drying cycles.

The drier irrigation regimes showed a decrease in shoot growth, while the roots developed equally well under all irrigation regimes. The percentage of water stable aggregates was not affected by the soil moisture regimes.

It can be concluded that Rohagit, applied to the soil at a concentration between 0.02% and 0.2%, caused an increase in the percentage of water stable aggregates, as was found in other experiments also (3, 6, 10). This soil condition caused more extensive root development and, therefore, small increases in water use efficiency were noted.

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