Impact of a Soil Conditioner on Some Selected Chemical Properties of a Calcareous Soil

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There is a paucity of information on the effects of gel-forming conditioners on soil chemical properties in arid and semiarid regions such as Saudi Arabia. We conducted a greenhouse pot experiment and examined the status of selected chemical properties of a calcareous sandy loam soil. The objective was to observe the effect of two irrigation intervals and a soil conditioner (Aquasorb) on selected soil chemical properties. Aquasorb at the rates of 0.0%, 0.2%, 0.4%, and 0.6% (by weight) was applied to the top 10 cm of soil in each pot. The treated and untreated soils were irrigated every 5 or 10 days and incubated for 45 days. There was no significant effect of the irrigation intervals on soil chemical properties after 45 days of incubation. Aquasorb application increased soil pH significantly, compared with the control in both soil layers (0–10 and 10–20 cm). Electrical conductivity was significantly higher in the upper soil layer of treated samples than the control and remained unchanged in the lower depth. Aquasorb application caused an increase in AB-DTPA-extractable Zn and a decrease in extractable Fe and Mn only in the upper soil layer. Extractable Cu, K, and P were not affected by Aquasorb application in either soil layer. These results indicate that application of gel-forming conditioner may have deleterious effects on some selected soil chemical properties.

Keywords soil conditioner, Aquasorb, pH, EC, plant nutrients

For several years, gel-forming soil conditioners have been widely used in agriculture to alleviate the unfavorable physical properties of coarse-textured soils in arid and semiarid regions such as Saudi Arabia. These highly absorbing materials proved to be effective in increasing water-holding capacity and decreasing deep percolation of sandy soils (Miller, 1979; Johnson, 1984; Al-Omran et al., 1987; Mustafa et al., 1988). Gel-forming soil conditioners have also been used to increase soil aggregation (Cheshire, 1979; Tisdall & Oades, 1982; Chaney & Swift, 1986; Al-Omran et al., 1987) and to increase infiltration capacity of soils (Wallace & Wallace, 1986; Mustafa et al., 1989). However, all of these reports on gel-forming soil conditioners have focused attention only on the effects on soil physical properties. In general, very limited research has been conducted on the influence of gel conditioners on soil chemical properties. A previous study by Falatah and Al-

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Mustafa (1993) has shown that addition of Jalma gel conditioner significantly increased the pH and decreased the extractable micronutrients of a calcareous soil.

The main objectives of the present study were to observe the interactive effects of two irrigation intervals and four rates of Aquasorb addition on selected chemical properties and nutrient extractabilities of a calcareous sandy loam soil.

Materials and Methods

Surface samples (0–25 cm) of a calcareous sandy loam soil (Typic Torripsamments) were collected from the College of Agriculture Experimental Farm at Deirab, Saudi Arabia. The samples were collected from three sites within the farm and composited. The soil was air dried and sieved through a 2-mm-mesh sieve. The soil pH and electrical conductivity (EC) were measured in a saturated paste, $CaCO_3$ was determined by acid neutralization (Allison & Moodie, 1965), and soil texture by a hydrometer method (Day, 1965). The air-dried soil was extracted with ammonium bicarbonate–diethylenetriaminepentaacetic acid (AB-DTPA) solution according to the method of Soltanpour and Schwab (1977). The extracted Zn, Fe, Mn, and Cu were determined by atomic absorption spectrophotometry, K was determined by flame photometry, and P by spectrophotometry. The results of these analyses are given in Table 1. The synthetic conditioner used was an organic gel-forming soil conditioner commercially known as Aquasorb. (The use of the trade name is for information and convenience to the reader. Such use does not constitute an official endorsement of the product.) The air-dried and sieved (2-mm mesh) soil was uniformly packed in plastic pots to achieve a bulk density of 1.50 Mg m^{-3}. The top 10 cm of soil in each pot was removed and thoroughly mixed by hand with an appropriate rate of Aquasorb and then replaced in the pot before irrigation. Treatments consisted of four concentrations of Aquasorb, 0.0%, 0.2%, 0.4%, and 0.6% (by dry weight), and two irrigation intervals, 5 and 10 days. The treatments were arranged in a split-plot design with four replications. The packed pots were wetted to field moisture by slowly adding water to the surface. Pots

Table 1.
Selected properties of a calcareous sandy loam, a Typic Torripsamment

Component	Value
pH	7.83
EC (dS m^{-1})	0.76
$CaCO_3$ (%)	28
AB-DTPA-extractable (mg kg^{-1})	
Zn	0.70
Fe	4.36
Cu	2.87
Mn	0.24
K	138
P	26
Textural components (%)	
Sand	77
Silt	12
Clay	11

were weighed immediately following the wetting to obtain estimates of pot weight at field capacity for subsequent calculations of water application volumes. Afterward, pots were weighed before each irrigation, and average moisture loss was calculated for each pot to determine the amount of water needed to achieve the desired moisture. Duplicate soil samples were taken from each pot after 45 days of incubation and analyzed for pH, EC, and AB-DTPA-extractable nutrients. The data were analyzed using SAS ANOVA (SAS Institute, 1982).

Results and Discussion

Soil pH and Electrical Conductivity

The soil pH was strongly affected by the rate of Aquasorb application (Figure 1), especially when the rate exceeded 0.2%. The increases in pH values were observed in both the top (0–10 cm) and the subsurface (10–20 cm) soil depths. Significant increases in pH were observed only in the soil samples receiving more than 0.2% Aquasorb. This observation is in partial agreement with a previous study by Falatah and Al-Mustafa (1993). In that study, the addition of soil conditioner (Jalma) was associated with an increase in soil pH. These findings may be partially attributed to the chemical composition of the synthetic soil conditioners that encourage supply of soil-exchangeable bases (Ca, Mg, K, and Na), thereby increasing the pH of the treated soil if the concentration of conditioner applied was high.

Figure 2 shows the effects of different application rates of Aquasorb on the EC values. An increase in Aquasorb concentration was associated with increases in EC values in the upper soil layer (0–10 cm). In the lower soil layer (10–20 cm) the EC values remained unchanged. The lack of any difference between these treatments in the lower soil

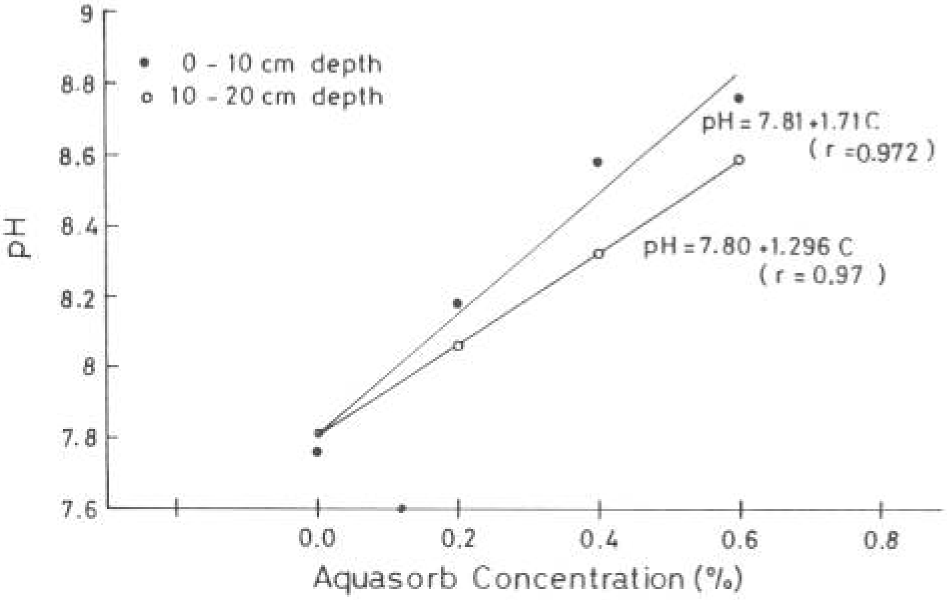

Figure 1. Effect of different rates of Aquasorb conditioner on soil pH.

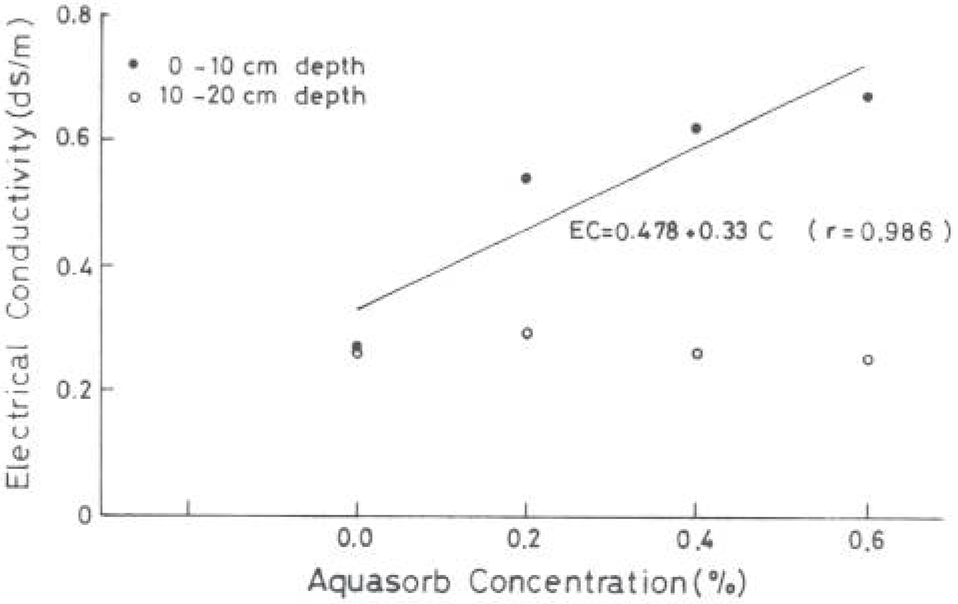

Figure 2. Effect of different rates of Aquasorb conditioner on soil EC.

layer is not clearly known. The different irrigation intervals had no significant effect on selected soil chemical properties.

Zinc

The amount of AB-DTPA-extractable Zn was influenced by the application of Aquasorb (Table 2). For the upper layer (0–10 cm), extractable Zn concentration was significantly higher in the pots treated with Aquasorb. Knowing the effects of Aquasorb on soil pH, one would expect that the solubility and extractability of Zn would decrease due to Aquasorb application. This finding contradicts the general concept of a decrease in extractable Zn with increasing pH (Lindsay & Norvell, 1969; Bar-Yosef, 1979; Shuman, 1975). Most of these studies, however, were done without an application of gel-forming conditioner. The relationship between pH and AB-DTPA-Zn was tested by running a regression analysis, and the result showed a high correlation coefficient ($r = 0.84$).

As the sampling depth increased (10–20 cm), Aquasorb addition showed no significant effect on extractable Zn, resulting in a low correlation coefficient ($r = 0.46$). Research is currently under way to investigate the relationship between different gel-forming conditioners and extractable Zn and other elements.

Iron

The effects of Aquasorb application rates on AB-DTPA-Fe are given in Table 2. The data show that an increase in concentration of soil conditioner (Aquasorb) caused a decrease in extractable iron at the 0- to 10-cm depth. This decrease was attributed to the increase in soil pH resulting from the Aquasorb application. The relationship between pH and AB-DTPA-Fe was confirmed by a high negative correlation ($r = -0.88$). At 10- to 20-cm depth, Aquasorb had no significant effects on extractable Fe.

Chemical properties of soil at two depths as influenced by rate of Aquasorb application

Aquasorb concentration (%)	AB-DTPA-extractable (mg kg^{-1})					
	Zn	Fe	Mn	Cu	K	P
			0- to 10-cm Depth			
0.0	0.74	4.56	2.93	0.25	134	26
0.2	0.98	3.24	2.80	0.24	128	28
0.4	1.34	2.78	2.34	0.26	122	33
0.6	1.65	2.54	2.22	0.26	125	30
LSD$_{(0.05)}$	0.21	0.38	0.63	0.03	21	9.2
			10- to 20-cm Depth			
0.0	0.73	4.31	2.88	0.27	137	28
0.2	0.69	3.84	2.84	0.25	132	26
0.4	0.75	3.78	2.78	0.27	135	24
0.6	0.73	3.81	2.77	0.26	134	28
LSD$_{(0.05)}$	0.24	0.75	0.53	0.02	21	8.5

LSD, least significant difference.

Manganese

The effect of Aquasorb application on AB-DTPA-Mn was similar to the effect on AB-DTPA-Fe (Table 2). For the 0- to 10-cm depth the concentration of extractable Mn was lower in the pots treated with higher rates of Aquasorb due to the increased pH values. There was a strong negative relationship between pH and AB-DTPA-Mn ($r = -0.90$), decreasing with increasing pH. The same trend was observed in the lower depth, but the differences were not significant.

Copper, Potassium, and Phosphorus

Aquasorb application had no effect on AB-DTPA-Cu, a result opposite to that of the other three AB-DTPA-extractable micronutrients measured in this study. Despite the high pH at both depths, there was no trend indicating that extractable Cu was affected by pH. This finding was similar to the results of Falatah and Al-Mustafa (1993) and Haynes and Swift (1985), where AB-DTPA and DTPA-extractable Zn were unaffected by soil pH.

Statistical contrasts among the treatments receiving Aquasorb show no significant difference ($p = 0.05$) in extractable K or P in either soil layer. In general, the upper soil layer samples treated with Aquasorb, compared with the control, had reduced AB-DTPA-extractable K and increased extractable P. In the lower soil layer, no consistent trends were observed.

Conclusions

The results indicated that application of Aquasorb soil conditioner had an unfavorable influence on selected chemical properties of a calcareous sandy loam soil. The data strengthen our conclusions of a previous study (Falatah & Al-Mustafa, 1993) that addition of gel-forming conditioner may cause deteriorative effects on soil pH, EC, and availability of some plant nutrients. Therefore, the addition of such conditioners to improve the physical properties of arid soils should be reconsidered due to their possible adverse effects on some soil chemical properties.

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