

Summary





5. SUMMARY

Sandy soils have their own problems which can be assembled in their single grain structure, high water requirements, susceptibility to erosion and drought and loss of both irrigation water and plant nutrients. Of the techniques that can be applied to modify hydrophysical properties of sandy soils and consequently improving plant-soil-water-fertilizers relations in such soils is the use of synthesized soil conditioners. Among these conditioners are super absorbent materials (hydrogel). The present work aims at studying the effect of such type of soil conditioners on hydrophysical Some economical crops-either of sandy soils. properties vegetables (Cucumber) or summer forage crops (Guar and Cowpea) were chosen in this study as the indicator plants to clarify the conditioning effect of hydrogels on quantities of irrigation watr needed for crop production from one side and quantities plant grwoth, yield and water and fertilizers use efficiency by such crops on the other side. Therefore, the work was divided into two parts, the first was conducted in the laboratory and the greenhouse, while the other was in the field.

I- Effect of incorporating hydrogels in sandy soil on its hydrophysical properties (Laboratory studies):

A virgin sandy soil: (Sand = 94.8%, 0.M.= 0.1%, CaCO₃ = 1.4%, pH = 7.9) from El-Shabab area, West Sinai, and hydrogel (propenamide polymer with hydrophilic groups (sulphonates) chemically crosslinked with a divalent vinyl monomer (K salt) "Evergreen 500-Austrian) were used. The soil was treated with the hydrogel at different rates (0.0, 0.1, 0.15 and 0.2% w/w of dry soil). Different indices were taken to evaluate the improving effect of the conditioner on certain hydrophysical and mechanical properties of the soil.

Obtained results could be summarized as follows:

1.a) Soil structure in the dry state was improved with increasing the amounts of hydrogel applied. Since soil with non-erodible structural units >0.84 mm exceeding 60% were considered as soil resistant to wind erosion and break down by tillage, the treated soil with hydrogel at 0.2% seems to be the most stable treatment. It shows the highest values of total and the most stable structural units >0.84 mm, the destructive mechanical action expressed by the number of rotations (W) or the time of dry sieving in minutes (t) needed to return the conditioned soil to its original stable state i.e. the

control and the lowest values of wind erosion parameter, instability parameter (SP) and deaggregation rate (RD).

- b) The structure of sandy soil treated with the hydrogel is stable in the wet state. The stability increases with application rate of the hydrogel. Water stable structural units >0.5 mm and MWD of the size distribution of water stable structural units reached 82.3% and 3.471%, respectively. Relevant values for the untreated soil were 7.2% and 0.071, in sequence.
- c) The formed structure maintained three cycles of complete destruction and re-formation without remarkable changes in either water stable structural units > 0.5 mm or the erosion index.
- 2. Whereas, the hydrogel decresed soil bulk density at saturation and after drying as well as the macro porosity, it increased void ratio, total porosity, the micro pores relative to the total or to the macro pores. Moacro:Micro porosity reached about 1:1 by applying the hydrogel to sandy soil at 0.2%. Water holding pores (28.8-0.19 u) were increased by 46.8, 90.0 and 157.2% on the expense of the drainable pores (> 28.8 u) which decreased by 9.9, 18.4 and 34.5% relative to that of the control by treating the soil with 0.1, 0.15 and 0.2% hydrogel, respectively.
 - 3. Retained moisture in sandy soils, at all suctions under study (from 0 to 15 bars) were increased by soil conditioning being higher with increasing the application rate of the hydrogel. Because the increase in water retained in the soil at field capacity (pF= 2.01) is far beyond that at wilting percentage (pF= 4.19), the available water in the treated soil with 0.2% hydrogel was increased to be about three times that of the control treatment. The decrease in air filled porosity of the conditioned soil is not likely to become limiting to plant growth since the air filled porosity did not reach 10%.
- The loss of water from sandy soil through evaporation reduced by soil conditioning. Under the conditions of the conducted experiments, the time required for saturated soils to reach their wilting percentages were 10.5, 19.1, 24.3 and 28.0 days with average evaporation rates of 1.482, 1.251 and 1.057 mm day for the untreated 2.086, soil and that treated with 0.1, 0.15 and 0.2% hydrogel, intermittent evaporation respectively. the Regarding columns experiment, and for all of the eight successive wetting and drying cycles, the conditioning treatments could be arranged according to their effect on reducing adjusted evaporation (Eadj) as follows:

hydrogel 0.2% > hydrogel 0.15% > hydrogel 0.1% > control. The minor changes in the values of Eadj over the eight cycles of wetting and drying reveal the stability of the formed structure due to the conditioning process and the

very low biodegradability of the examined hydrogel.

5. Values of infiltration rate reveal the relatively high infiltration rate of the untreated sandy soil (2 0.85 cm min⁻¹). Incorporating 0.1, 0.15, 0.2% hydrogels in the soil lowered its infiltration rate by 10.6, 20.0 and 29.4%, respectively.

6. Incorporating 0.2% hydrogel in sandy soil decreases its mean pore diameter by 37.9% and in turn its hydraulic conductivity decreases by 61.4% relative to those of the

untreated soil.

7. The increase in soil mechanical strength of air dry soilexpressed by the unconfined compressive strength, penetration resitance and the modulus of rupture — is not so high to limit the use of such hydrogel at a rate of 0.2% for sandy soil conditioning.

II- Field studies on the effect of hydrogel used as conditioners for sandy soils, on the growth response and water and fertilizers use efficiency by some economical crops:

Experiment 1:

A completely randomized field experiment with replications for each treatment was conducted in a virign sandy soil at West Sinai to study the effect of two hydrogels namely Evergreen 500 Austrian (polyacrylamide K sulphonate gel) (DOW, Absorbent Laminates), American) Water germination, plant growth, nutrients uptake and both water and fertilizers use efficiency by the plants. Cucumber was chosen as the indicator plant. Either the crystals of the hydrogel (Evergreen 500) at the rate of 4 g/plant pit or the laminates of the hydrogel (DWAL) at the rate of 0.24 m²/plant pit were in the soil at a depth of 15 cm from the soil incorporated Controlled surface irrigation was applied at the rate surface. of 100 m3/fed/irrigation Examined irrigation intervals were 4(normal irrigation). 8 and 12 days. All other agricultural practices including mineral fertilization were the same.

Obtained results could be summarized as follows:

1- Addition of hydrogel to sandy soil enhances the germination process. The time needed for 50% emergence (T_{50}) was reduced by 2.1 and 1.3 days with the hydrogels

Evergreen 500 and DWAL, respectively.

2- Significant increases in plant height, number and area of leaves and the dry weight of plants were obtained by sandy soil conditioning. Increments in the dry weight of plants were amounted to 121 and 85% for DWAL, and 154 and 107% for evergreen 500 over that of the control treatment at the two irrigation intervals 8 and 12 days, respectively. 3- Postive effects on the uptake Of N. P and K by Cucumber plants were achieved. Increments in nutrients uptake by plants over that of the control arrived to be 187 and 93% for N, 181 and 155% for P and 109% for K when watering

the soil every 8 and 12 days, respectively.

4- Using hydrogels-as conditioners for sandy soil markedly raises its productivity. The increase in the yield of Cucumber differed by the type of added hydrogel irrigation regime. Obtained yield increased by 37 and 21% for DWAL treatments and 57% and 29% for Evergreen 500 treatments when the soil was irrigated every 8 and 12

days, respectively.

Applied materials resulted in a considerable reduction in water consumption and therefore a significant the improvement in the water use effeciency by plants was obtained. Increments in the water use efficiency by plants expressed as kg of the marketable yield obtained by each cubic meter of the irrigation water used, compared to the control treatment were 105 and 264% for DWAL and 136 and 288% for Evergreen 500 at the two irrigtion intervals 8 and 12 days, respectively.

The marketable yield obained from conditioned sandy soil by each unit of added nutrients refer to the beneficial effect of hydrogels on increasing the fertilizers use efficiency by plants that ranged between 1.2 and 1.6 times

that of the untreated soil.

Experiment 2:

A two successive years completely randomized experiment with four replications for each treatment was conducted at Salhia to study the effect of treating virgin sandy soils with hydrogels on yield and both water and fertilizers use efficiency by Guar and Cowpea as of the main summer forage crops. The used hydrogel in this experiment was a polyacrylamide K sulphonate gel (Evergreen 500, Austrian) at the rates of 0.0, 33.3, 66.6° and 100 g/m^3 soil. Controlled the rates of 100 applied at irrigation Was m³/fed/irrigation. Examined irrigation intervals were 4 (normal irrigation), 8 and 12 days. All other agricultural practices including mineral fertilization were the same. The following parameters were determined; a) fresh and dry weight of the obtained yield b) water use efficiency by plants. and c) fetilizers use efficiency by plants.

Obtained results could be summarized as follows:

1- a- Fresh and dry weights of obtained plants were positively affected by gel treatments. Under the same irrigation regime both fresh and dry weights incresed by increasing the application rate of the hydrogel.

b- Doublling the irrigation intervals for the plants grown in the treated soil with hydrogels has increased both the fresh weights and the dry weights of plants to reach maximum when 100 g of the examined hydrogel/m² soil was applied.

c-Reducing the applied irrigation water to the third resulted in a little decrease in the fresh and dry weight yields. However, the production was still much higher than that under the control. In this case when 100 g of the hydrogel were added to each m² of the soil, the increase compared to the control treatment were 125 and 64% for the fresh weight yield and 121 and 65% for the dry one of Guar and Cowpea crops, respectively

2- a- Produced yield by the unit of either irrigation water or added fertilizers refer to the beneficial effect of the hydrogel for raising the productivity of sandy soil, reducing water consumption and increasing both water and fertilizers use efficiency by plants.

b— The highest water use efficiency value lies at 100g hydrogel/m² soil when the soil was irrigated every 12 days. This was about 5.8 and 4.8 times that of the control treatment for Guar and Cowpea in sequence.

c- Fertilizers use efficiency by Guar produced in sandy soil treted with 100 g hydrogel/m² soil and irrigated every 8 days has reached 2.25 times that of the untreted soil irrigated every 4 days. Relevant value for cowpea was 2.0 times.

Obtained results may prove the importance of using hydrogels for conserving irrigation water and increasing crops production of the sandy soils under the severe conditions of i.e., the limited water resources the and our deserts, inadequate water retention and low fertility of these soils. When evaluating the use of such products as conditioners for sandy soils, one has to take in consideration the improvement of the hydrophysical properties and the nutritional status of the soil, the increase in the yield and the saving costs of the irrigation water and fertilizers on one side and the costs of the product itself and costs of the conditioning process on the other side.