

## **Influence of Water Quality on Water Absorption Capacity of Soil Gel-conditioners**

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**Abstract.** A laboratory experiment was conducted to investigate the effect of water quality on water absorption capacity (WAC) of soil gel-conditioners. The gel-conditioners used included AcryHope (AH), Culture Plus (CP), StaWet (ST), and Hydrogel (HD). The water used different in electrical conductivities (EC; 0.5, 1, 2, 4, and 8 dSm<sup>-1</sup>) and sodium adsorption ratio (SAR; 5, 10, and 20).

The results showed that the amount of water absorbed decreased with increased salinity. However, the rate of reduction decreased as SAR increased. This suggests that a high SAR of water may enhance the water absorption capacity of soil gel-conditioners. Thus it is very important to consider the EC and SAR of the irrigation water during the selection and management of soil gel-conditioners. To aid this process of soil gel-conditioners selection and management, linear relationships were established between the relative WAC and natural logarithm of EC for all soil gel-conditioners with the exception of AH in which SAR is included.

### **Introduction**

Various synthetic organic polymers with long flexible molecules have been introduced as soil conditioners. These conditioners are often described as superabsorbent of water, forming an amorphous gelatinous mass or discrete gel particles, depending on their original dehydrated physical form [1]. The synthetic gel-conditioners are recognized for soil water properties improvement, especially of sandy soils in arid areas where water is scarce.

It is important to consider the interactive effects of water quality on the selection and management of the soil gel-conditioner to be used. This is more important in arid areas as Saudi Arabia where irrigation waters (ground water) are commonly medium to saline [2]. The possibility of utilizing diluted sea water for irrigation is being explored.

Thus the purpose of this study was to investigate the joint effects of total salinity and sodium adsorption ratio (SAR) on the water absorption capacity of soil gel-conditioners.

### Materials and Methods

The synthetic gel-conditioners used in this experiment were AcryHope (AH), Culture Plus (CP), StaWet (ST), and Hydrogel (HD). Additional information on these conditioners is given in Table 1. The water used included distilled water and 15 mixed  $\text{CaCl}_2$  -  $\text{NaCl}$  salt solutions differing in electrical conductivities (EC; 0.5, 1, 2, 4, and 8  $\text{dsm}^{-1}$ ) and sodium adsorption ratio (SAR; 5, 10, and 20) to simulate a wide range of irrigation waters normally encountered in arid areas. The airdried gel-conditioner (0.2 g) was added to 100 g of water, differing in quality, in 250 ml beaker. The beaker was covered with aluminum foil to prevent water evaporation. The mixture was equilibrated overnight at room temperature (25°C) to ensure a complete absorption of water by different conditioners. The excess water was then removed using filter paper and then weighed. The water absorption capacity (MAC) was equal to the water added minus water not absorbed. For meaningful comparison between gel-conditioners regarding the rate of salinity effect on WAC, the relative WAC (RWAC) was calculated as the WAC of each gel-conditioner with the treatment in question divided by its inherent WAC with distilled water. Each treatment was replicated thrice. The RWAC data were subjected to appropriate statistical techniques for comparing the different treatments.

### Results and Discussion

The determined water absorption capacities of the four gel-conditioners using distilled water were different from those reported by the manufacturer (Table 1). The determined WAC with distilled water for the four soil gel-conditioners ranked as follows: CP > HD > AH > ST. These differences between soil gel-conditioners were related to their physiochemical properties (Table 1). Notice that CP is a hydrophilic polymer.

Figure 1 presents the effect of EC and SAR values of water on the relative water absorption capacity (RWAC) for four soil gel-conditioners. The effect of the EC of the water was highly significant ( $P < 0.01$ ) regardless of SAR level for all soil gel-conditioners. The RWAC, in general, significantly decreased as EC increased. However, this rate of decrease was reduced as EC increased. In most cases, an EC = 4 to 8  $\text{dsm}^{-1}$  is shown to reach the maximum reduction. This is more true with SAR = 5. This maximum reduction was usually over 90%. Al-Gosaibi *et al.* [3] showed that the maximum EC value causing reduction in water absorption capacity of polyacrylamide soil gel-conditioner was about 6.3  $\text{dsm}^{-1}$ . It seems that the total salts dissolved in irrigation water retained the water and suppressed the gel particles. Mustafa

*et al.* [4] and Al-Darby *et al.* [5] reported a decrease in swelling of soil treated with soil gel-conditioners with increase in water salinity and suggested a  $6.4 \text{ dsm}^{-1}$  as a critical EC value.

Generally for all soil gel-conditioners, the effect of SAR on RWAC was significant with  $\text{EC} > 1 \text{ dsm}^{-1}$ . The effect of EC on RWAC decreased as SAR increased. This reduction was generally more pronounced at  $\text{EC} > 1 \text{ dsm}^{-1}$  and  $\text{EC} < 8 \text{ dsm}^{-1}$ . It seems that the SAR of the water has a modified effect on decreasing water absorption by the soil gel-conditioners. This may be due to the hydrolysis effect of high number of Na ions present in the water absorbed. This finding agrees with that of Hussain *et al.* [6], but it disagrees with that of Al-Gosaibi *et al.* [3], who observed a decrease in WAC with increase in SAR of water. Accordingly, they suggested that increased SAR of water could be a limiting factor for poor gel-conditioners response. Thus it may be suggested here that SAR of water enhanced the ability of soil gel-conditioners to absorb water. However, one should be careful in using irrigation water with high SAR value due to its detrimental effect on soil physical properties and consequently on plant growth.

Quantitative assessments of the overall effect of EC on RWAC resulted in a linear relationship between RWAC and natural logarithm of EC and was calculated for each SAR levels. A statistical test described by Johnston [7, P. 207] was used to detect differences between the parameters of the linear relationships across SAR levels for each soil gel-conditioners. The correlation coefficients ( $r$ ) of all regression lines were highly significant ( $P < 0.01$ ). The statistical test revealed no significant differences between the corresponding parameters of ST, HD, and CP soil gel-conditioners. Thus ST, HD, and CP soil gel-conditioners can be represented each by one regression line taking into consideration only EC levels (inset equations Fig. 1). It should be noted that ST and HD soil gel-conditioners have almost the same slope and intercept and thus can be combined in one equation as follows:

$$\text{RWAC} = -0.2068 \ln \text{EC} + 0.4492 \quad (r = -0.9449)$$

This identical behavior of ST and HD soil gel-conditioners may be related to their similar chemical properties (Table 1), in which both contain starch and monovalent cations acrylate.

For AH soil gel-conditioners, the slopes and intercepts of RWAC vs. in EC regression lines across SAR levels were significantly different ( $P = 0.05$ ) from each other. The slopes were  $-0.2593$ ,  $-0.2403$ , and  $-0.1831$  for SAR 5, 10, and 20, respectively. Thus SAR levels must be taken into consideration in addition to EC levels for AH soil gel-conditioner. The suggested equation for AH soil gel-conditioner is as follows:

$$\text{RWAC} = -0.2276 \ln \text{EC} + 0.0066 \text{SAR} + 0.4823 \quad (r = -0.9615)$$

These types of relationships may prove useful as a guide for soil gel-conditioner selection and management.

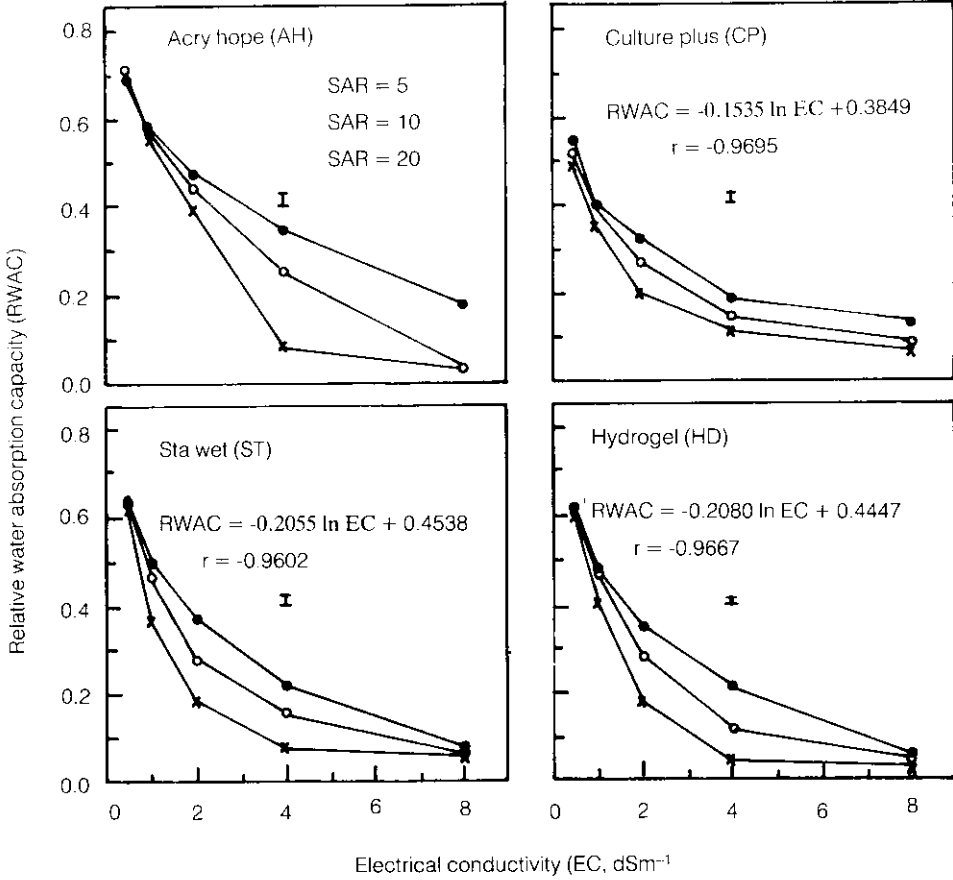
In general, AH was on the average the least affected soil gel-conditioner by EC and SAR levels when compared to other soil gel-conditioners on the basis of RWAC as defined in the text, followed by ST, HD and then CP (Fig. 1). In addition, AH was the only soil gel-conditioner among the tested ones to display an overall effective modified effect due to increase in SAR, in which RWAC increased with increase in SAR. However, comparing soil gel-conditioners on the basis of the average WAC relative to the highest WAC of CP (see Table 1) or on the basis of the average absolute values of WAC, over all EC and SAR levels ranked as follows: CP > AH > HD > ST.

**Table 1.** Properties of soil gel-conditioners used in the study.

Product name <sup>1</sup>	manufacture name <sup>1</sup>	Chemical properties	Water absorption capacity for distilled water	
			Reported <sup>2</sup>	determined
AcryHope (AH)	Nippon Shokubai Kagaku Kogyo Co., Ltd. Japan	Crosslinked Sodium polyacrylate	g g <sup>-1</sup> 250	g g <sup>-1</sup> 218.3
StaWet (SW)	Polsorb, Inc. Smeltonville, ID., U.S.A.	Starch-grapht-poly, (acrylamide-Co-Na Acrylate)	50 times Peatmoss	137.5
Hydrogel (HD)	Finn Co. Cincinnati U.S.A.	(Starch- poly- Co- K- Acrylate)	1000	256.9
Culture Plus (CP)	—————	Hydrophilic-synthetic poly.	200-700	337.5

1- Trade and company names and address included for the benefit of the reader, and do not imply endorsement by King Saud University.

2- Reported by the Manufacturer



**Figure Legends**

**Fig. 1.** The effect of electrical conductivity (EC,  $\text{dSm}^{-1}$ ) and SAR values of water on relative water absorption capacity (RWAC) for four soil gel-conditioners. Vertical bars represent LSD at 0.01 level.

### References

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## تأثير نوعية المياه على مقدرة محسنات التربة الجيلاتينية على امتصاص الماء

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ملخص البحث. أجريت دراسة معملية لتحديد أثر نوعية المياه على مقدرة محسنات التربة الجيلاتينية على امتصاص الماء. ولقد استخدمت محسنات التربة الجيلاتينية التالية: أكرى هوب AcryHope وستاويت StaWet وهيدروجل Hydrogel وكلشر بلص Culture Plus. وكانت الاختلافات بين نوعية المياه تتركز في قيمة التوصيل الكهربائي (EC؛ ٥، ١٠، ٢٠، ٤٠، ٨٠ ديسي سيمنز/م وأيضاً في قيمة نسبة امتصاص الصوديوم (SAR؛ ٥، ١٠، ٢٠).

أوضحت النتائج أن كمية الماء الممتص من قبل محسنات التربة الجيلاتينية قد إنخفض بازدياد ملوحة المياه. ولكن هذا التأثير قل عند إرتفاع قيمة الـ SAR للمياه وهذا يختلف باختلاف درجة ملوحة المياه ونوعية محسن التربة الجيلاتيني. وهذه النتيجة تشير إلى أن قيمة الـ SAR العالية نافعة لزيادة قدرة محسنات التربة الجيلاتينية على امتصاص الماء. وعليه فإنه من الضروري جدّاً الأخذ في الاعتبار قيمة الـ EC والـ SAR لمياه الري عند اختيار واستخدام وإدارة محسنات التربة الجيلاتينية. وللمساعدة في اختيار وإدارة محسنات التربة الجيلاتينية، فقد نشأت علاقات خطية بين القدرة النسبية على امتصاص الماء واللوغاريتم الطبيعي للـ EC لجميع المحسنات فيما عدا الأكري هوب حيث أضيف إليها الـ SAR.

