Testing super-absorbent hydrogels in vineyards subjected to drought and summer stresses

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INTRODUCTION

- New superabsorbent hydrogels (SH) could be groundbreaking technologies for the adaptation of agriculture to climate change.
- Low and/or irregular rainfall and extreme summer temperatures pose serious issues to vineyards under establishment.

AIM OF THE STUDY

- Aim of the present study was to elucidate if SH can improve soil water holding capacity and if the additional available water is held at soil water potential thresholds compatible with grapevine root uptake, thus improving vine water status under stressful conditions. Three different SH were tested on potted vines and in field at vineyard establishment.

M&M

- In this work, the three following hydrogels (Figure 1) were tested in lab, and then applied to grapevines cv. Sangiovese grown in pots, and in-field on grapevines cv. Sauvignon Blanc at vineyard establishment:

1. **SH1:** a granular potassium polyacrylate super-absorbent hydrogel
2. **SH2:** a crystal potassium polyacrylate super-absorbent hydrogel.
3. **SH3:** an organic material (lignin-sulfonates) derived superabsorbent hydrogel.

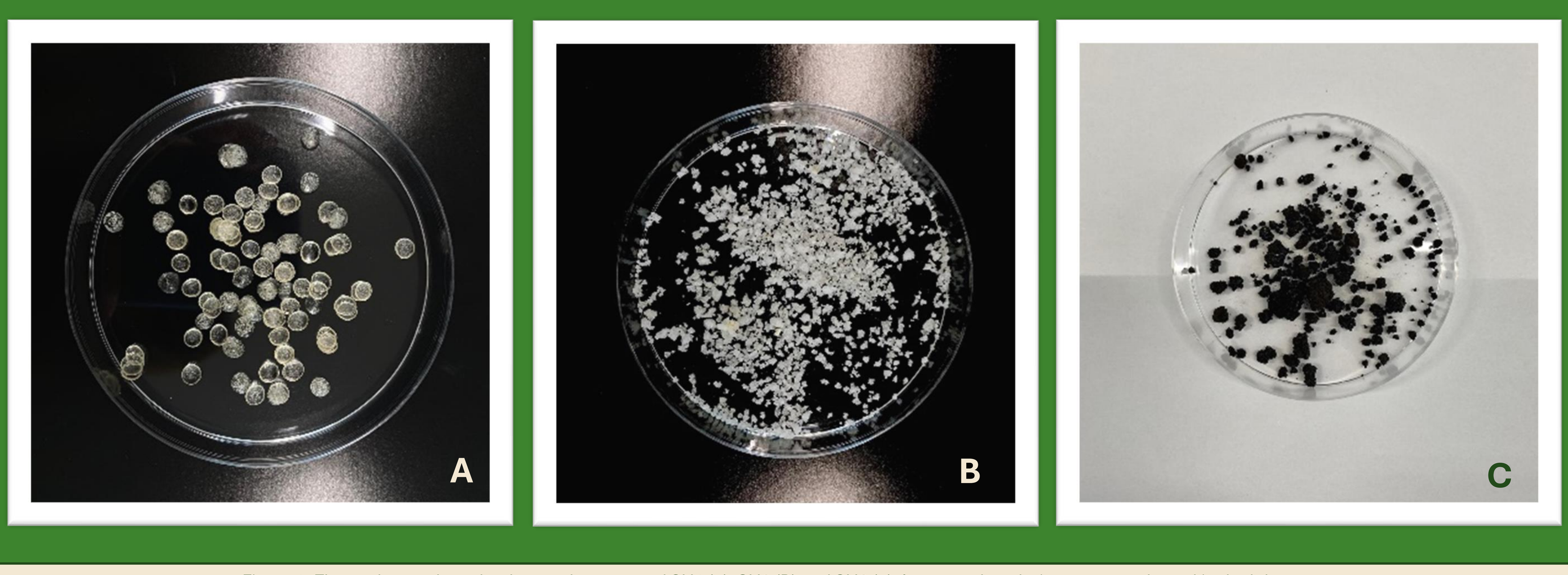

Figure 1- These photos show the three polymers used SH1 (a), SH2 (B) and SH3 (c). Images taken during tests conducted in the laboratory.

CONCLUSIONS E PERSPECTIVES

- SH could represent a new frontier in tree crops water management under climate change.
- Localized SH applications can significantly improve vineyard establishment, potentially reducing vine mortality and duration of unproductive stages.
- Data demonstrate that SH can locally improve soil hydrology and vine tolerance to drought, paving the way for multiple vineyard water saving strategies.

RESULTS

- At full hydration, the three SH exhibited a Ψ close to 0 MPa (Figure 2). At decreasing water concentration, the three SH showed a progressive and different decrease of Ψ. About 90% of the absorbed water was made available at Ψ compatible with *Vitis vinifera* root uptakes (Ψ<-1.5 MPa).

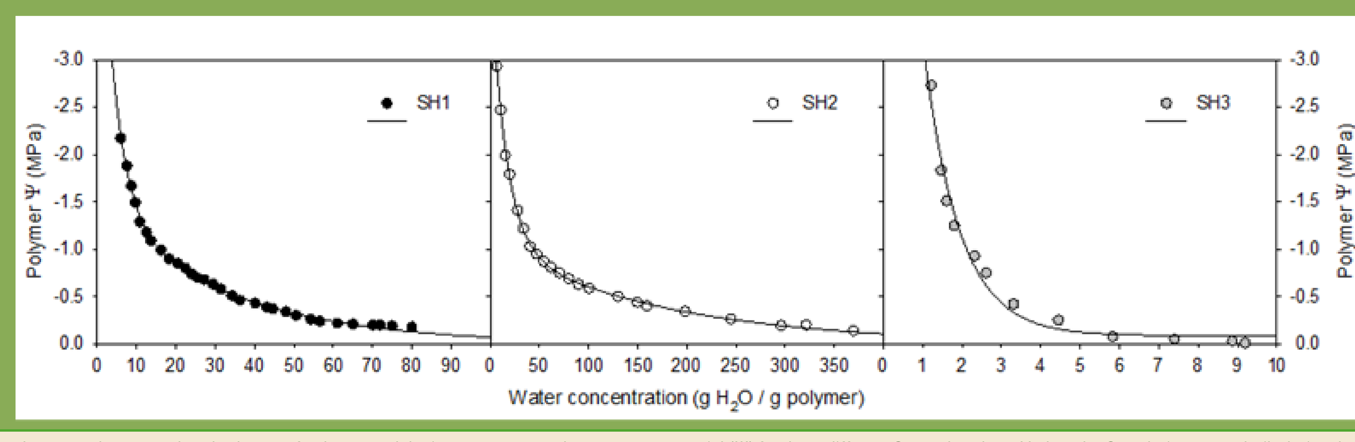

Figure 2 - Correlation between the water absorbed per g of polymer and the instantaneous polymer water potential (Ψ) for three different Superabsorbent Hydrogels. Correlations were built during the dehydration process. SH1= Granular potassium polyacrylate hydrogel y= -4.42*exp(-0.25x)-1.49*exp(-0.03x) R^2=0.999; SH2= Crystal potassium polyacrylate hydrogel y= -2.95*exp(-0.06x)+1.06*exp(-0.01x) R^2=0.999; SH3= Lignin-sulfonates derived Hydrogel y= -1.23-11.29*exp(-1.10x)+1.14*exp(-0.01x)+1.90*exp(-1.10x) R^2=0.991.

- In absence of SH, the substrate had a field capacity (θ_{fc}) of 0.24 gH_2O/g (Table 1). All the SH increased also the permanent wilting point (θ_{pwp}), but each of them significantly increased the maximum plant available water (AWC) (from +0.10 gH_2O/g in SH2 to +0.19 gH_2O/g in SH1).

Table 1 – Physical traits of a sandy clay loam soil when added of three different Superabsorbent Hydrogels. SH1= Granular potassium polyacrylate hydrogel; SH2= Chrystal potassium polyacrylate hydrogel; SH3= Lignin-sulfonates derived Hydrogel.

	θ_{fc} [1] ($g\ H_2O/g$ Soil)	θ_{fc}-2 [1] ($g\ H_2O/g$ Soil)	t [2]	θ_{pwp} [1] ($g\ H_2O/g$ Soil)	Maximum AWC [1] ($g\ H_2O/g$ Soil)	Water loss 30°C ($g\ H_2O/g$ Soil/h)	Water loss 40°C ($g\ H_2O/g$ Soil/h)	t [2]
Soil	0.24 ± 0.01 b [3]	0.25 ± 0.01 c	ns	0.01 ± 0.01 c	0.23 ± 0.02 c	0.12 ± 0.02 a	0.16 ± 0.02 c	*
Soil + SH1	0.45 ± 0.01 a	0.46 ± 0.03 a	ns	0.03 ± 0.01 b	0.42 ± 0.01 a	0.12 ± 0.01 a	0.25 ± 0.01 a	*
Soil + SH2	0.43 ± 0.02 a	0.44 ± 0.01 a	ns	0.10 ± 0.02 a	0.33 ± 0.02 b	0.08 ± 0.01 b	0.15 ± 0.01 c	*
Soil + SH3	0.42 ± 0.02 a	0.38 ± 0.02 b	ns	0.08 ± 0.01 a	0.34 ± 0.01 b	0.12 ± 0.01 a	0.19 ± 0.01 b	*
Sig. [4]	***	***		***	*	**	***	

[1] θfc= field capacity; θfc-2= field capacity after at the 2nd cycle of sample hydration. θ_{pwp}= permanent wilting point; AWC= Available Water Content.
[2] * indicates significant difference between different parameters within the same treatment (Student's t-test). ns = no difference
[3] Different letters indicate significant difference between treatments per P<0.05 (SNK test).
[4] *,**, and *** indicate significant difference between treatments per P<0.05, 0.01 and 0.005, respectively (n=3). ns means no difference.

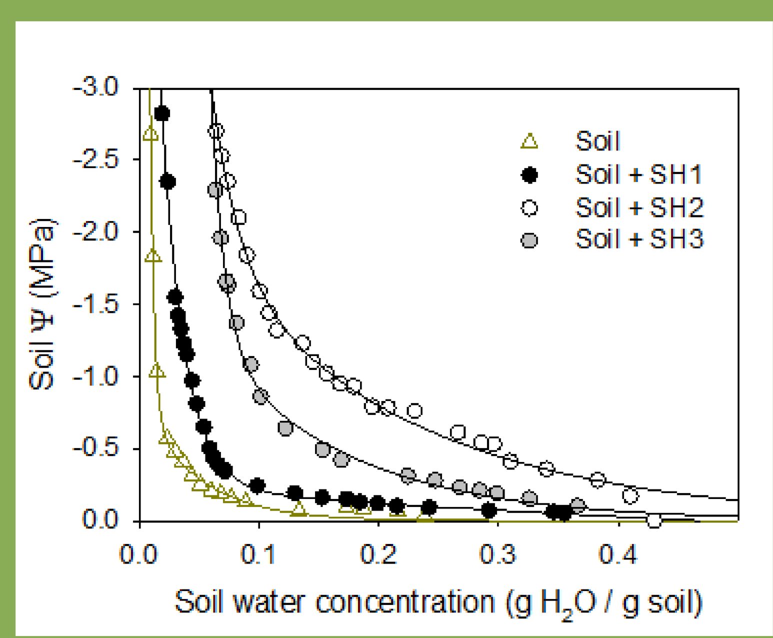

Figure 3 - Correlation between the soil water content and the instantaneous soil water potential for a sandy clay loam when added of three different Superabsorbent Hydrogels. Correlations were built during the dehydration process. SH1= Granular potassium polyacrylate hydrogel 2.06 mg/g soil; SH2= Chrystal potassium polyacrylate hydrogel 0.62 mg/g soil; SH3= Lignin-sulfonates derived Hydrogel 23 mg/g soil. Soil: y= -0.19-14.52*exp(-194.39x) R^2=0.991; Soil+SH1: y= 0.42-6.93*exp(-52.38x) -0.66*exp(-0.96x) R^2=0.999; Soil+SH2: y= -16.11*exp(-42.93x) -2.49*exp(-5.72x) R^2=0.996; Soil+SH3: y= -23.55*exp(-8.42x) +21.57*exp(-8.42x) -305.25*exp(-86.25x) R^2=0.997.

- In absence of SH, a dramatic reduction of soil Ψ for water concentrations lower than 0.7 g H_2O/g soil was observed (Figure 3). Incorporation of any of the three SH made water available at concentrations ranging between 0.24 and 0.43 g H_2O/g soil; otherwise, water corresponding to such range was subjected to drainage.

- Local applications of SH1 (30 g/plant) and SH3 (100 g/plant) prior to vineyard establishment increased pre-dawn water potential (by 0.04 MPa and 0.06 MPa, respectively, Figure 4) and midday leaf water potential as compared to the Control (Figure 5).

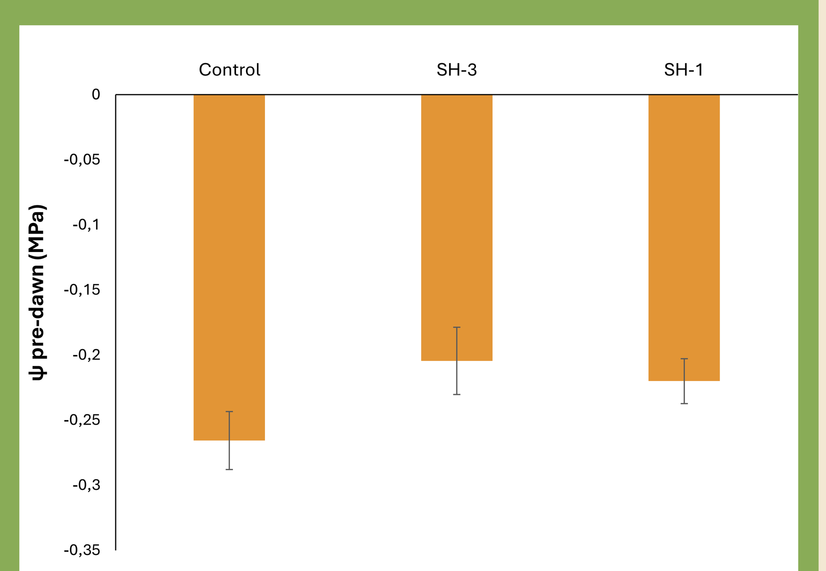

Figure 4 - Pre-dawn water potential measurement on SH1= Granular potassium polyacrylate hydrogel (30 g/plant) and SH3= Lignin-sulfonates derived Hydrogel (100 g/plant).

Figure 5 – A Scholander chamber was used to monitor pre-dawn (a) and midday leaf water potential (b).

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VINIDEA

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