THE EFFECT OF AQUASORB ON SOME MORPHO-PHYSIOLOGICAL PARAMETERS OF THE PLANTS UNDER THE PEDOCLIMATICAL CONDITIONS FROM MOLDAVIAN PLATEAU

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Abstract

The study aimed to outline the influence of hydrogel (Aquasorb) on some morpho-physiological parameters of the plants (number of grains per cob pods per plant, average height and chlorophyll content in leaves) for maize and soybean crops. Aquasorb is a copolymer of acrylamide and potassium acrylate that has the ability to absorb water and to release it progressively in the plant according to their needs. The experiment was bifactorial, AxB type, being located under the pedoclimatic conditions of the Moldavian Plateau from Ezareni Farm (47°5'- 47°10' N lat. 27°28'-27°33' E long.). The experimental field had a slope of 3-4 % with a clay-loamy texture of cambic chernozem soil. The soil had a medium content of N and P and good content of K, slightly acid pH and 2.5 – 3.0 % humus content. The experimented factors were the crop (maize and soybean) and hydrogel doses with three graduations (V_1- control variant, not treated; V_2- soil was treated with 15 kg ha^{-1} Aquasorb; V_3 – soil was treated with 30 kg ha^{-1} Aquasorb). The hydrogel was incorporated with a disk harrow at 15 cm depth, during seedbed preparation, in spring. The results outlined that the plants height registered large differences on treated variants compared with the control one especially at 30 days after their sprung up, which shows that the hydrogel provide a good start in plant vegetation and implicitly many advantages in the fight against weeding. The average content of chlorophyll in leaves was increased in hydrogel treated variants; depending on the Aquasorb dose. The values varied between 1.5 to 2.9 CCI (chlorophyll content index) for maize and between 1.2-1.9 CCI for soybean.

Key words: hydrogel, Aquasorb, morpho- physiological parameters, maize, soybean

In Romania, almost 64% of agricultural areas are more or less affected by long droughts periods and in consecutive years (Ulea E. *et al*, 2012; Hurduzeu G. *et. al*, 2014; Mateescu E., Alexandru D., 2010). Using hydrogel for soil conditioning, a part of the area affected by degradation processes such as, drought may be restored and returned to the agricultural circuit. Auasorb is a hydrogel, a copolymer of acrylamide and potassium acrylate. The hydrogel has the ability to function in absorption-desorption cycles of water and nutrients, releasing them to the plants accordingly with their requirements (Hany El-Hamshary 2007; An Li, *et al*, 2005; Farrell C. *et al*, 2013; Sepaskhah A.R., Bazrafshan-Jahromi A.R., 2006) and it has efficiency in soil for 5 years.

The water was available for longer periods in soils treated with hydrogel compared with untreated being noticed a decrease in irrigation frequency and lowering the irrigation costs implicitly (Sharma J., 2004; Agaba H *et. al*, 2011). Allahdadi I. *et al*, 2005 notified that the hydrogel application in an amount of 4g kg^{-1} of soil decrease the water requirements to 66% compared with the control lot.

The polyacrylamide improves soil hydro-physical properties determining an increased soil resistance to water and wind erosion and to the structural damages due to the soil tillage. The soil pores diameter and also water evaporation decreased, resulting an increased amount of available soil water. Also, it was noticed a lower pH and a higher nitrogen content in the sandy soil treated with polyacrylamide (El-Hady O.A., Abd El-Kader A.A., 2009).

The processes of germination, plant growth, nutrients takeover, efficient water and fertilizers utilisation rate have significantly increased when sandy soils were treated with hydrogels (Ouchi S. *et al,* 1990; Nus J.E., 1992; Smagin A.V., Sadovrikova N.B., 1995; Nadler A. *et al,* 1996; El-Hady O.A. *et al,* 2001, 2002, 2003, 2006; Callaghan T.V. *et al,* 1988).

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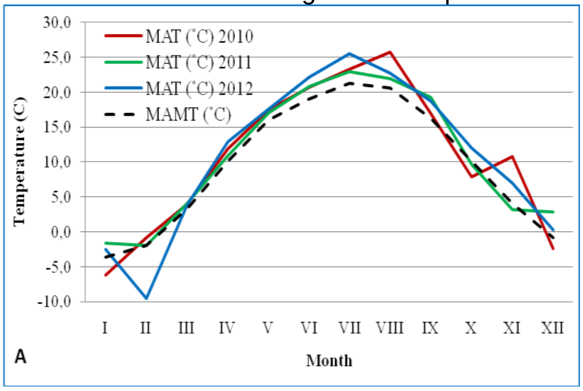
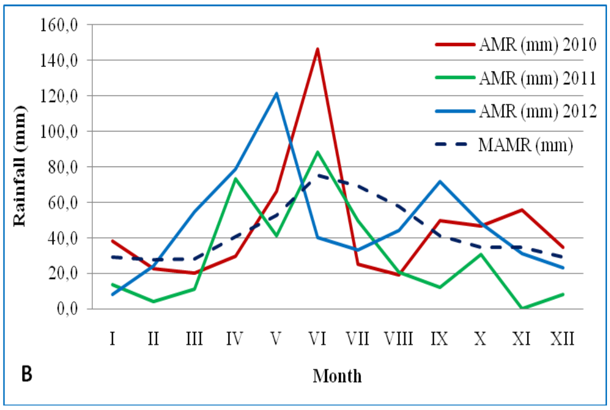
This study aims to bring new data regarding the possibilities to increase the productivity of agricultural land exposed to risk factors such as, drought which is manifested widespread and could be framed in the global climate change.

MATERIAL AND METHOD

The experiment was bifactorial, of AxB type, using the randomized blocks method, with three replicates. The experimental factors were represented by crop (maize and soybean) and Aquasorb doses. The hydrogel doses were applied in 3 variants: V_1 - untreated variant, V_2 – variant treated with 15 kg ha^{-1} of Aquasorb and V_3 variant treated with 30 kg ha^{-1} of Aquasorb. The Aquasorb was administered in spring, before seedbed preparation during disk harrowing, at 15 cm depth.

The study was carried out under the pedo-climatic conditions of the Moldavian Plateau, to the Ezareni Farm, which belongs to "Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine", Iași. The terrain has a slope of 3-4 %, the soil being a cambic chernozem, with medium to good fertility (medium content of nitrogen and phosphorus and good content of potassium), with 2.5 – 3.0% humus and low acid pH. In *figure 1* (A - temperature, B - rainfall) are presented the climatic conditions throughout the study.





MAT - Multi-annual temperature
MAMT - Multi-annual average temperature

AMR - Average monthly rainfall
MAMR - Multi-annual average rainfall

Figure 1 **Characterization of climatic factors for 2010-2012**
(A – air temperature, B – rainfall)

The used technology was specific for the analyzed crops, respectively maize and soybean. The fertilizers were administered at a dose of 60 kg ha^{-1} P_2O_5 + 40 kg ha^{-1} N prior seedbed preparation and 20 kg ha^{-1} N during vegetation to the first mechanical weeding for maize. For the soybean crop the total amount of nitrogen was administered before seedbed preparation. The seedbed was prepared on the sowing day, using the kompaktor cultivator. The seeding was performed with SPC 4 Planter + U650 for maize and with SPC 6 Planter +U650 for soybean crop. There were used Pioneer cultivars for both crops respectively, PR38A24 for maize and PR91M10 for soybean. Soybean was sown when the soil temperature was minimum of 7-8˚C, corresponding to average daily temperatures of 14-15˚C, at a rate of 90 kg ha^{-1}. The sowing was done in strips of three rows at 45 cm, with 60 cm between them, to 4-5 cm depth. The maize was sown when the soil temperature has reached 10°C, at a depth of 8-10 cm and 70 cm between rows, ensuring the maximum density recommended by the producer for non-irrigated crops - 65000 plants ha^{-1}. During the vegetation stage weeding operations were done mechanically and manually. For weed control were also used chemical measures such as, preemergent herbicide treatment with Dual Gold 960 EC (1.0 l ha^{-1}), for controling annual monocotyledonous and some dicotyledonous weeds (*Setaria sp., Echinochloa sp., Digitaria sp., Amaranthus sp., Chenopodium sp., Hibiscus sp.*). During the growing stage were used Basagran (2.0 l ha^{-1}) insert in soybean and Dicopur D (1.0 l ha^{-1}) for maize crop.

There were determined the average number of grains per cob (maize) and pods per plant (soybean), the average plant height and the chlorophyll content. In order to determine the average plant height, measurements were carried out as follows, after 30 days from sowing, during the vegetation stage and at harvesting. The samples were taken in three replications with 15 plants each for both crops. Plant height was determined with a standard meter-stick measuring from the soil surface to the highest point of the plant (Freemanet et al, 2007, Hager, 2010).

For the maize crop, three replicate determinations were done in order to count the number of grains per 15 cobs. Similarly, the number of pods per soybean plant was determined by counting 15 plants, with three replicate determinations. The counting was done with a Sadkiewicz electronic seed counter (Liu *et al*, 2011).

The leaf chlorophyll content was measured using the CCM 200 plus device from *Opti-Science (figure 2)*.

It is a device used for measurements in the field and does the precise, reliable and easy determination of the leaf chlorophyll content. It can store up to 4000 measurements, made with a detector with two photo-diodes and absorbance detector. The determinations were carried out approximately after 30 days from sowing, in early and late July, to the upper, middle and lower part of the plants, to highlight the Aquasorb influence on the plant development. The data had been stored on the internal memory, and after being downloaded on the PC, and at the end were processed using ANOVA and the F test.

Figure 2 **Device for determining the chlorophyll content of leaves (http://www.envcoglobal.com)**

RESULTS AND DISSCUSSION

Grains per cob / pods per plant

The average number of grains per cob and pods per plant respectively, were directly influenced by the hydrogel treatment. Thus, all variants registered significantly differences (*table 1*). For the control variant, the average number of grains per cob was 508.4 (*table 1*) and for the Aquasorb treated variants were obtained results higher with 10.4 grains and 18.9, respectively depending on the applied hydrogel dose. The same trend was noticed to soybean crop. The average number of pods per plant was 21.2 to the control variant and for the hydrogel treated one, the values raged between 22.7 and 24.0 pods.

The differences between all variants are due to the hydric stress periods which have a negative influence on plants growth and development. Its negative effects were partially attenuated by applying Aquasorb. The hydrogel has an important role in delaying the critical points when negative effects are triggered due to the hydric stress.

A higher number of pods per plant and grains per cob assured a higher crops productivity; similar results were presented insert by other researchers (Dorraji *et al*, 2010; Yang *et al*, 2014).

Table 1

The influence of Aquasorb on productivity elements

Variant	Maize (Grains per cob)				Soybean (Pods per plant)			
	Grains per cob	Compared to control		Significance	Pods per plant	Compared to control		Significance
		%	Differences (grains)			%	Differences (pods)	
V_1 – Control (untreated)	508.4±52.40	100.00	0.0	Control	21.2±1.37	100.00	0.0	Control
V_2 (15 kg ha^{-1} Aquasorb)	518.8±48.04	102.0	10.4	x	22.7±1.81	107.1	1.5	x
V_3 (30 kg ha^{-1} Aquasorb)	527.3±48.79	103.7	18.9	xx	24.0±0.71	113.2	2.8	xxx

LSD 5% = 9.4 grains; LSD 1% = 13.4 grains; LSD 0.1% = 19.4 grains; LSD 5% = 1.2 pods/pl; LSD 1% = 1.7 pods/pl; LSD 0.1% = 2.5 pods/pl

Note: x – significant, xx – distinctly significant, xxx – very significant, LSD – Least Significant Difference

Average plant height

The data analysis for both crops, showed that applying the hydrogel had a positive influence on plants average height in the vegetation stages when this parameter was determined (*table 2*). Similar results were obtained in research done on tomato and cucumber crop by El-Hady O.A. *et al,* 2001, 2002, 2003, 2006; Gales D.C., *et al,* 2016. The Aquasorb treatment offers many advantages to plants against the weeding especially in the first development stages, knowing that those are the most critical ones for the analyzed crops. Each vegetation stage analysis highlights that the Aquasorb positive effect on plants height is shown immediately after the plants rising, that being the plant critical point against weeding (*table 2*). Thus, for the maize crop, the variant treated with 30 kg ha^{-1}, the plants were higher than the control variant with 5.8% at approximatively 30 days from sowing, with 1.6% during the vegetation and with 2.5% to harvesting (*table 2*). The same trend was noticed to the soybean crop, the values obtained being higher with 14.7% after plant rising, with 4.2% during vegetation and 5.5 % to harvesting than the control variant (*table 2*).

Table 2

The influence of the Aquasorb on the average plant height in maize and soybean crop
(average values 2010-2012)

Growing stages	Variant	Maize Plant height				Soybean Plant height			
		cm	Compared to control		Significance	cm	Compared to control		Significance
			%	Differences (cm)			%	Differences (cm)	
Sowing	V_1	44.8±1.83	100.0	0.0	Control	15.5±0.45	100.0	0.0	Control
	V_2	45.6±1.37	101.8	0.8	NS	16.8±0.45	107.8	1.2	xxx
	V_3	47.4±2.04	105.8	2.6	xx	17.8±0.66	114.7	2.3	xxx
		LSD 5% = 1,7 cm	LSD 1% = 2.4 cm		LSD 0.1% = 3.5 cm	LSD 5% = 0.6 cm	LSD 1% = 0.8 cm		LSD 0.1% = 1.2 cm
Vegetation	V_1	239.7±3.20	100.0	0.0	Control	73.9±1.13	100.0	0.0	Control
	V_2	242.2±3.10	101.0	2.5	NS	76.6±0.61	103.6	2.7	xx
	V_3	243.6±4.24	101.6	3.9	NS	77.0±1.28	104.2	3.1	xxx
		LSD 5% = 4,9 cm	LSD 1% = 7.0 cm		LSD 0.1% = 10.1 cm	LSD 5% = 1.4 cm	LSD 1% = 1.9 cm		LSD 0.1% = 2.8 cm
Harvest	V_1	236.5±1.90	100.0	0.0	Control	86.2±1.05	100.0	0.0	Control
	V_2	243.3±2.08	102.9	6.8	xxx	88.8±1.15	103.0	2.6	xx
	V_3	242.3±2.58	102.5	5.8	xxx	90.9±0.90	105.5	4.7	xxx
		LSD 5% = 2.8 cm	LSD 1% = 3.9 cm		LSD 0.1% = 5.7 cm	LSD 5% = 1.3 cm	LSD 1% = 1.9 cm		LSD 0.1% = 2.7 cm

Note: xx – distinctly significant, xxx – very significant, NS – insignificant, LSD – Least significant difference, V_1 – Control (untreated), V_2 - 15 kg ha^{-1} Aquasorb, V_3 - 30 kg ha^{-1} Aquasorb

The chlorophyll content in leaves

The photosynthesis is influenced by internal and external factors. Cristea M. et al, 2004 appreciates that external factors are represented by light and lighting interval, CO_2 concentration, temperature, water, relative air humidity, mineral matter and oxygen. The internal factors are species, leaf structure, leaf age, chlorophyll content and accumulation of assimilates in the leaves. The chlorophyll formation is the most important physiological process which determines and characterises the plant accommodation reaction to various factors action such as, temperature, light, salt concentration of the soil solution, the atmospheric humidity and soil moisture.

Chlorophyll content in leaves was influenced by the hydrogel treatment for both crops. The noticed differences varied between 1.5- 2.9 CCI for maize crop, depending on the Aquasorb doses. To the control variant, the chlorophyll content in leaves was in average 47.3 CCI (*table 3*).

Table 3

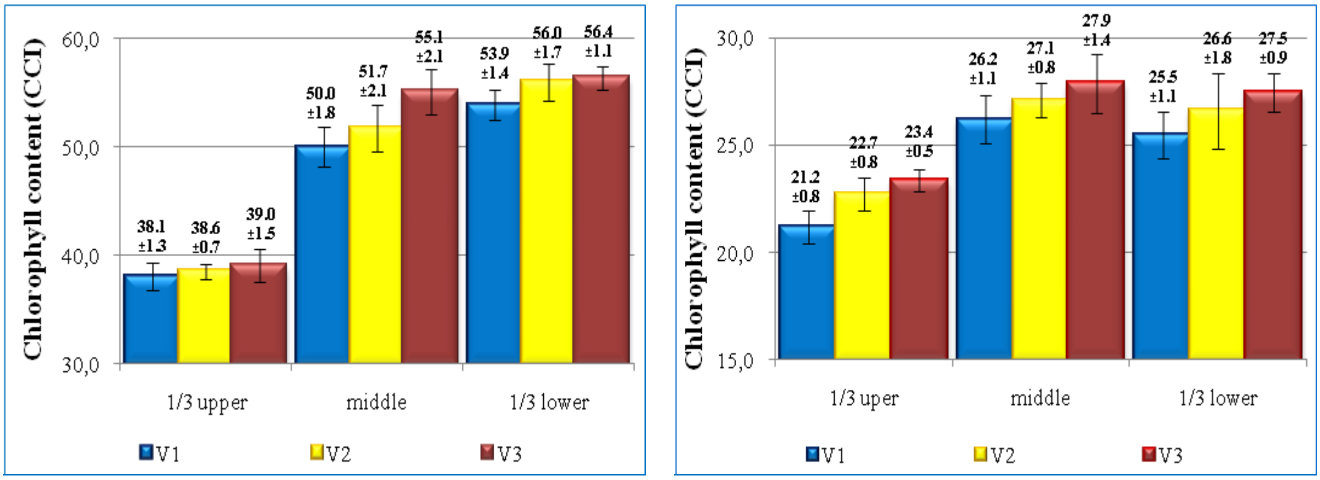
The influence of Aquasorb on the chlorophyll content in maize and soybean leaves
(average values 2010-2012)

Variant	Maize chlorophyll content				Soybean chlorophyll content			
	CCI	Compared to control		Significance	CCI	Compared to control		Significance
		%	Differences (CCI)			%	Differences (CCI)	
V_1 – Control (untreated)	47.3±1.37	100.00	0.0	Control	24.3±0.64	100.00	0.0	Control
V_2 (15 kg ha^{-1} Aquasorb)	48.8±1.10	103.17	1.5	x	25.5±0.61	104.94	1.2	x
V_3 (30 kg ha^{-1} Aquasorb)	50.2±0.86	106.13	2.9	xx	26.2±0.67	107.82	1.9	xxx
	LSD 5% = 1.5 CCI	LSD 1% = 2.1 CCI		LSD 0.1% = 3.0 CCI	LSD 5% = 0.9 CCI	LSD 1% = 1.3 CCI		LSD 0.1% = 1.8 CCI

Note: x – significant, xx – distinctly significant, xxx – very significant, LSD – Least significant difference.

The same results were noticed to soybean crop. Differences were registered between the hydrogel treated variants and the control, being higher with 1.2 CCI for V_2 and 1.9 CCI for V_3. The chlorophyll average content for the control variant was 24.3 CCI (*table 3*). The chlorophyll content in leaves varied throughout the plant. Thus, for the maize crop was noticed that the chlorophyll content was maximum in the lower part of the plant, medium in the middle and minimum to the upper part (*figure 3*). For the soybean crop, the chlorophyll content was maximum in the middle part, medium in the lower plant part and minimum in the superior part of the plant. This differentiation is due more to plant morphology and not because of the hydrogel influence in plants growth and development. But, the interest lays in the differences noticed to the treated variants compared to control one; the chlorophyll content was maximum in the upper third of the plant, medium in the lower third and minimum in the plant median part (*figure 3*).

During the research was noticed that the chlorophyll content in leaves increased along with the plant growth, the maximum being obtained after blooming. In this vegetation stage were also recorded the highest differences in chlorophyll content between treated and untreated variants.



Maize Soybean

Figure 3 **Chlorophyll content in maize and soybean leaves (average values on years and growing stage)**
V_1 – Control, V_2 – 15 kg ha^{-1} Aquasorb, V_3 – 30 kg ha^{-1} Aquasorb.

CONCLUSION

The results obtained so far show that the Aquasorb influences the plant growth and development in all growing stages, a more significant influence being noticed during the periods in which the rainfall had a relative uneven distribution. During those periods, the plants from the treated variants had suffered less due to the hydric stress because the applied hydrogel created a water reserve which assured an easy transition over hydric stress periods or even its avoidance when the water reserve was not used entirely.

Using the hydrogel Aquasorb in crop technology can be seen as a technical solution that helps to reduce the costs using more efficiently the water where the irrigation systems are installed and also may be considered as an "insurance policy" against some undesirable phenomena such as medium intensity droughts.

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