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Original Article

The Influence of Aquasorb on Maize and Soybean Yield and Economic Efficiency in Moldavian Plain Native

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Abstract

The trial was established in 2010 in the Didactic Station of the University of Agricultural Sciences and Veterinary Medicine "Ion Ionescu de la Brad" Iasi, Ezăreni farm. The purpose of the research was to introduce in field crops technology a synthetic macromolecular compound known as Aquasorb. In this study we aimed to evaluate the influence of hydrophilic polymer Aquasorb on yield and the economic efficiency of its use in maize and soybean crops in the climatic conditions of Iasi County. The experience was polifactorial, AxBxC type, designed as randomized blocks with three replications. The experimental factors were: the crop, the dose and the administration time of the polymer. The dose of 15 kg/ha Aquasorb (V_2) and 30 kg/ha (V_3) were compared with the untreated control (V_1). The polymer was incorporated in the spring of 2010 on one half of the experimental plot (50 m^2) with disc harrow before sowing and in autumn of 2010 with tillage on the other half of the experimental plot (50 m^2). The statistical analysis showed a positive influence of Aquasorb treatment on yield in both crops analyzed, the positive effect of the polymer being exploited by plants depending on rainfall distribution. The results showed that there is a direct influence on economic efficiency in the analyzed crops, and the most effective cost is at a dose of 15 kg/ha Aquasorb, both for maize crop and soybean.

Keywords: Hydrogel, hydrophilic polymer, Aquasorb, water retention.

1. Introduction

The study answers the need for food safety and security worldwide, as part of current concerns, domestic and international, on improving growth conditions and species adjustment to new biotic and abiotic stress conditions caused by global climate changes. In the last fifty years, productivity frontier was considered to be the increase of the land efficiency use, ie obtaining higher yields per hectare, but in the 21st century, the new frontier is to increase water productivity - getting a greater benefit from each liter of water used for agricultural purposes [7].

The use of hydrophilic polymers can be considered a technical solution that meets some modern agrotechnical problems such as water retention in the soil, this problem being manifested more frequently due to increased alternation between periods of drought and periods with relatively large amounts of rainfall. Hydrophilic polymers absorb normally an amount of distilled water of hundreds of times their weight [1]. Polyacrylamide-based polymers are used when persistent drought inhibits plant growth, because they improve water storage properties in the soil pores. Highly absorbent polymers with low binding tension between pF 2.0 to 4.2, are of great use in agriculture, horticulture and forestry, in drought-prone areas [6].

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The processes of germination, plant growth, nutrient acquisition and efficient use of water and fertilizers by plants are positively influenced by hydrophilic polymers [2, 3, 4, 8, 9, 10, 11].

We find the macromolecular compound tested under the commercial name of Aquasorb. This is a copolymer of acrylamide and potassium acrylate *(*fig. 1), and when is incorporated into the soil or substrate is able to absorb high quantities of water and nutrients that are gradually passed to the plants according to their consumption. The polymer operates in absorption-desorption cycles of water and nutrients.

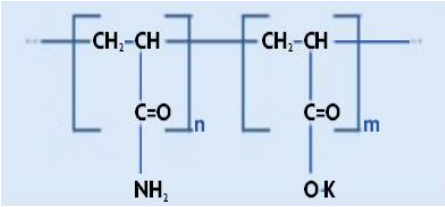


Figure 1. Aquasorb structure

The trial was established in 2010 at Ezăreni farm, belonging to the Didactic Station of University of Agricultural Sciences and Veterinary Medicine "Ion Ionescu de la Brad" Iasi, located in Miroslava (47° 07' N, 27° 30' E).

The plots were located on a slope of 3 - 4%, cambic chernozem soil type, clay loam, with weak acidic pH, humus content of about 2.5 to 3.0 %, middle supplied in N and P_2O_5 and well supplied in K_2O (table 1). In the above conditions, three variants in three replications were designed after randomized blocks method (V_1 - version control, untreated, V_2 - treated with 15 kg/ha Aquasorb, V_3 - treated with 30 kg/ha Aquasorb).

The plots had an area of 100 m^2 and were treated with Aquasorb as it follows: 50 m^2 were covered in spring of 2010, before sowing, by incorporating polymer with disc harrow, and in autumn, the other half of 50 m^2 plot was treated by incorporating the polymer with plowing to a depth of 25 cm.

Table 1. Chemical properties of cambic chernozem from Ezareni Farm (0-40 cm soil profile)

Crop	Depth (cm)	pH	Humus, %	Nt, %	P AL, mg/kg	K AL, mg/kg
Maize	0-10	6.32	2.88	0.11	34.00	174.0
	10-20	6.40	2.88	0.10	23.00	171.0
	20-30	6.51	2.76	0.09	19.00	166.0
	30-40	6.51	1.50	0.07	6.00	149.0
Average 0-40 cm		6.44	2.51	0.09	20.50	165.0
Soybean	0-10	6.27	3.54	0.10	27.00	195.0
	10-20	6.29	2.94	0.11	27.00	192.0
	20-30	6.40	3.18	0.10	18.00	167.0
	30-40	6.72	2.70	0.08	8.00	155.0
Average 0-40 cm		6.42	3.09	0.10	20.00	177.3

The technology was specific for the crops analyzed, respectively maize and soybean. The fertilizers were administered at a dose of 60 kg/ha P_2O_5 + 40 kg / ha N before seedbed preparation and 20 kg/ha N in vegetation at first mechanical weeding for maize, and for the soybean crop the total amount of nitrogen was administered before seedbed preparation.

The seedbed was prepared on the day of sowing, using the kompaktor cultivator and the seeding was performed with SPC4-FS + U650 for maize and with SPC6 +U650 for soybean crop. Pioneer hybrids were used both in maize (PR38A24) and soybean (PR91M10).

Soybean was sown when the soil temperature reached a minimum of 7 - 8˚C, corresponding to average daily temperatures of 14 - 15˚C, at a rate of 90 kg/ha. The sowing was done in strips of three rows at 45 cm, with 60 cm between them, at 4-5 cm depth.

The maize was sown when the soil temperature has reached 10°C and rising, 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. A mechanical and two manual weeding operations were made during the vegetation season.

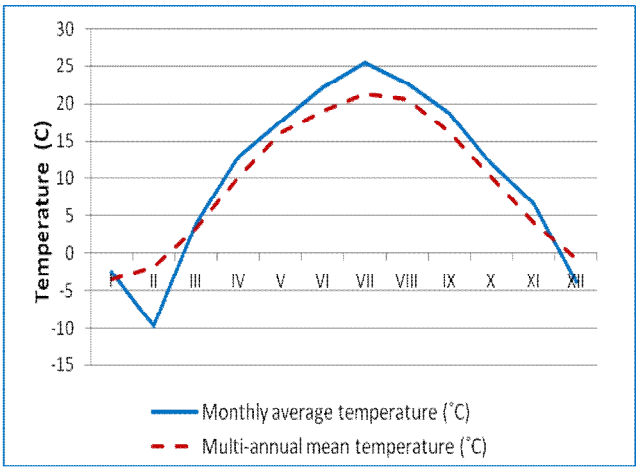
Besides agrotechnical measures for weed control, chemical measures were also used: a preemergent herbicide treatment with Dual Gold 960 EC (1.0 - 1.5 l/ha), against annual monocotyledonous and some dicotyledonous weeds (*Setaria sp., Echinochloa sp., Digitaria sp., Amaranthus sp., Chenopodium sp., Hibiscus sp.*). Basagran (2-2.5 l / ha) in soybean and Dicopur D (1.0 l/ha) in maize were used during crops growing season.

3. Results and Discussions

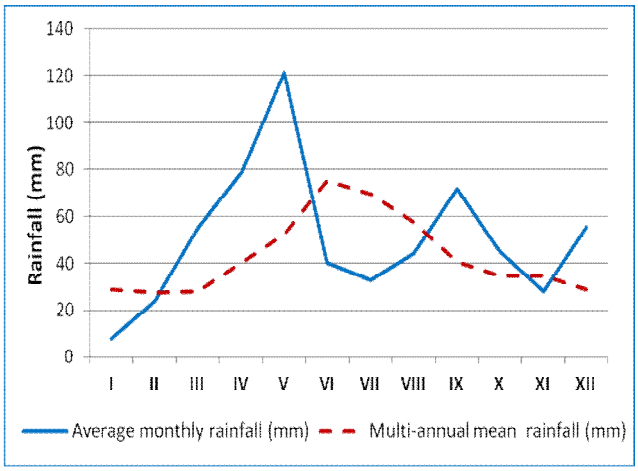
The agricultural year 2012 was characterized by higher temperatures compared to the annual average for this area (fig. 2A) and the rainfall had a very uneven distribution (fig. 2B), with relatively large differences from one phase of

crop vegetation to another. High rainfall in the spring have created optimal conditions for germination and crop emergence, but in the months that followed drought caused serious plant growth problems.

The fact that there have been consecutive months without notable rainfall that could have be exploited by plants, created a generally gloomy picture and the plants suffered, especially the spring crops. Thus, the maize crop in some areas of the country had shown a rare phenomenon that is plants rejuvenalization [5]. The plants didn't silk and those who silked, have not produced any seed. This phenomenon occurred because the drought and heat that were reported in June-August period, and in August there were high rainfalls in a short period of time. Under these conditions, in the plants without cob, cob bouquets with silk suddenly reappeared, but there was no more pollen, so the yields were compromised.



A: Temperature in 2012



B: Rainfall in 2012

Figure 2. Weather conditions in 2012

I: The analysis of Aquasorb influence on yield in maize and soybean crops in 2012. With such a general picture, less favorable in terms of climatic conditions, the positive effects of hydrophilic polymer Aquasorb were better highlighted by registering of significant yield increases both for maize crop and soybean.

In maize crop, the yields varied depending on dose and time of administration of the polymer between 5104 - 5330 kg/ha, while in the control variant there were obtained 4183 kg/ha, the differences being very significant.

The yield growth varied depending on the dose of polymer administered between 921 to 945 kg/ha for polymer T_1 period of administration and between 1128 to 1147 kg/ha for polymer T_2 period of administration (table 2A).

Table 2. The influence of the hydrophilic polymer Aquasorb and its administration period on yield in maize and soybean crops

Crop	Variant	Time*	Yield kg/ha	Yield % of control	Difference (kg/ha)	Significance
A: Maize	V_1 – Control (untreated)		4183	100.0	0	Mt
	V_2 - 15 kg/ha Aquasorb	T_1	5104	122.0	921	xxx
		T_2	5311	127.0	1128	xxx
	V_3 - 30 kg/ha Aquasorb	T_1	5128	122.6	945	xxx
		T_2	5330	127.4	1147	xxx
	T_1 DL 5% = 170.9 kg/ha		T_1 DL 1% = 243.0 kg/ha		T_1 DL 0.1% = 351.0 kg/ha	
	T_2 DL 5% = 212.2 kg/ha		T_2 DL 1% = 301.7 kg/ha		T_2 DL 0.1% = 436.8 kg/ha	
B: Soybean	V_1 – Control (untreated)		1629	100.0	0	Mt
	V_2 - 15 kg/ha Aquasorb	T_1	1865	114.5	236	xxx
		T_2	2018	123.9	389	xxx
	V_3 - 30 kg/ha Aquasorb	T_1	1982	121.7	353	xxx
		T_2	2166	133.0	537	xxx
	T_1 DL 5% = 45.1 kg/ha		T_1 DL 1% = 64.1 kg/ha		T_1 DL 0.1% = 92.8 kg/ha	
	T_2 DL 5% = 74.4 kg/ha		T_2 DL 1% = 105.8 kg/ha		T_2 DL 0.1% = 153.2 kg/ha	

* T_1 - polymer incorporated with the disc harrow before sowing in spring 2010, on one half of the experimental plot (5/10 m - 50 m^2);
* T_2 - polymer incorporated under the autumn plowing after plant harvesting, in the autumn of 2010, on one half of the experimental plot (5/10 - 50 m^2).

The same trend was observed with soybean crop, i.e. under the influence of polymer, plants have better used the rainfall, which ultimately contributed in achieving higher yields in variants treated with polymer compared to the control and the differences were statistically significant. The yield increased with 236 kg/ha in variant V_2T_1, 389 kg/ha in V_2T_2, 353 kg/ha in V_3T_1 and with 537 kg/ha in V_3T_2, compared to the control variant V_1 where the yield was 1629 kg/ha (table 2B).

The yield was higher in Aquasorb treatments compared to the control due to the higher humidity, especially in water stress conditions during grain formation and filling, and on the other hand due to the indirect effect of higher humidity which contributed in obtaining larger plants with a higher chlorophyll content, thus increasing the efficiency of vegetation factors.

II: The analysis of the economic efficiency of Aquasorb use in maize and soybean crops in 2012. Table 3 presents an estimating and planning expenses guide, by which the total costs were determined for each crop. When calculating the data in *table 4* there was used an Aquasorb price of 64.5 lei/kg, and the calculation was made considering that the polymer is effective in the soil for five years. The price of the technology which included the polymer was increased by the cost of conventional technology with 193.5 lei/ha in variants treated with 15 kg/ha Aguasorb and with 387 lei/ha in variants treated with 30 kg/ha Aquasorb (1 euro = 4.3 lei).

Table 3. Planning and estimating guide of costs maize and soybean crops

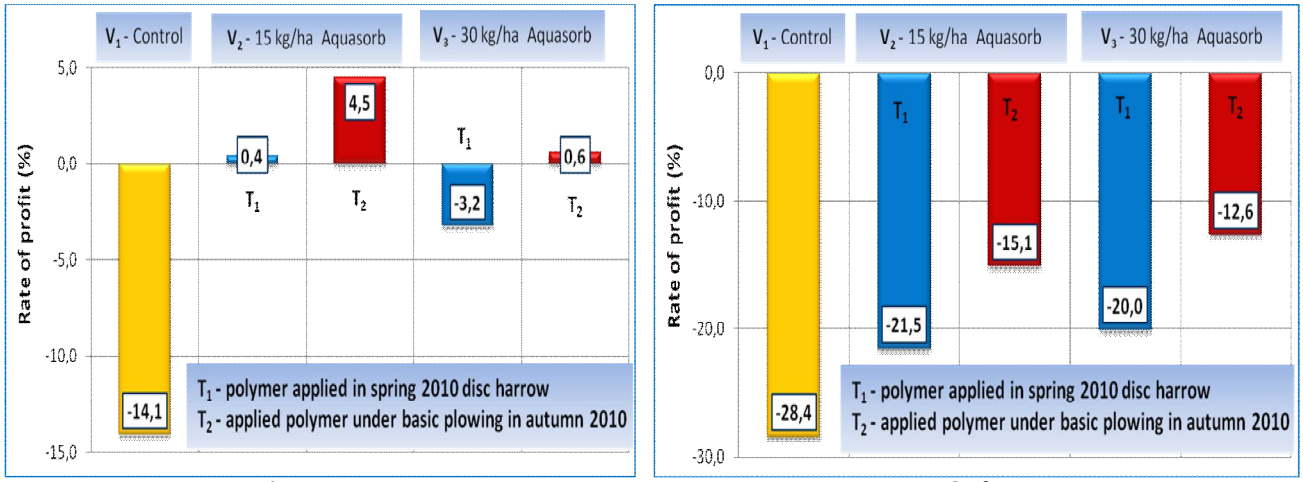
Specification	Maize (lei/ha)	Soybean (lei/ha)
1. Seeds	503	594
2. Chemical fertilizers	1533	1533
3. Herbicides	134	365
4. Fuels	505	464
5. Repairs and maintenance of machineries	50	50
6. Crop Insurance	36	36
7. Seeds drying / conditioning	0	0
8. Interest related circulating capital	0	0
9. Other costs (harvesting with third parties)	350	330
Total variable costs	3110	3372
10. Depreciation of investment in field works + rent	43	43
11. Depreciation of farm machinery	82	82
12. Interest on fixed capital	47	47
13. Crop insurance	36	36
14. Storing and preserving agricultural products	0	0
15. Manpower and management	1063	744
Total fixed costs	1271	952
Total variable and fixed costs	4381	4323

An analysis of the results showed that Aquasorb treatment influenced the profit rate in both crops with administration timing and rate. Water stress recorded in 2012 highlighted the usefulness of the Aquasorb treatment which greatly reduced drought losses and determined even profitable results. Thus, in maize the profit rate was increased by 14.5 % in V_2T_1, by 18.6 % in the V_2T_2, by 10.9 % in V_3T_1 and by 14.7 % in V_3T_2 (fig. 3A). In soybean the profit increased by 6.9 % in the V_2T, by 13.3 % in the V_2T_2, by 8.4 % in V_3T_1 and by 15.8 % in V_3T_2 version (fig. 3B).

Table 4. The economic efficiency in maize and soybean crops

Crop	Variant	Time*	Yield (kg/ha)	Total costs (lei)	Production value (lei)	Gross profit	Rate of profit
A: Maize	V_1 – Control (untreated)	T_1	4183	4381	3765	-616	-14.1
	V_2 – 15 kg/ha Aquasorb	T_1	5104	4574	4594	19	0.4
		T_2	5311	4574	4780	206	4.5
	V_3 – 30 kg/ha Aquasorb	T_1	5128	4768	4615	-153	-3.2
		T_2	5330	4768	4797	29	0.6
B: Soybean	V_1 – Control (untreated)	T_1	1629	4323	3095	-1228	-28.4
	V_2 – 15 kg/ha Aquasorb	T_1	1865	4517	3544	-973	-21.5
		T_2	2018	4517	3834	-682	-15.1
	V_3 – 30 kg/ha Aquasorb	T_1	1982	4710	3766	-944	-20.0
		T_2	2166	4710	4115	-595	-12.6

T_1 - polymer incorporated with the disc harrow before sowing in spring 2010, on one half of the experimental plot (5/10 m - 50 m^2);
* T_2 - polymer incorporated under the autumn plowing after plant harvesting, in the autumn of 2010, on one half of the experimental plot (5/10 - 50 m^2).



A – Maize B - Soybean

Figure 3. The influence of the hydrophilic polymer Aquasorb and its administration period on rate of profit in maize and soybean crops

4. Conclusions

Between the variants treated with Aquasorb and the control versions there were reported statistically significant differences in yield and these themselves varied in direct proportion to the increase of polymer dosage for maize and soybean.

Introducing of the hydrophilic polymer Aquasorb in crop technology can be seen as a technical solution that helps at reducing costs by increasing water use efficiency where the irrigation systems are installed and on the other hand can be considered as an "insurance policy" against some undesirable phenomena such as medium droughts.

In terms of profitability it is recommended a dose of 15 kg/ha Aquasorb, both for maize crop and soybean.

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