RESEARCH ON THE INFLUENCE OF GROWTH REGULATORS ON THE WATER REGIME OF SOYBEAN PLANTS IN THE CONTEXT OF CLIMATE CHANGE IN CENTRAL MOLDAVIA

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Abstract

Soybean is a globally valued and sought-after crop due to its high protein and oil content in the beans, as well as its ecological adaptability. Water is an indispensable component for plant life, and its absence is the most important abiotic factor negatively influencing the quality and quantity of agricultural yields. Analyzing the climatic conditions in Central Moldavia, there has been an observed increase in temperatures in recent years, coupled with a reduction in precipitation. This paper presents the results obtained from a bifactorial experiment aimed at determining the influence of growth regulators on the water regime of soybean plants in response to climate change, achieved through the application of different growth regulator treatments. The experiment was conducted in the experimental field of A.R.D.S. Secuieni in the year 2023. According to the determinations made, the rate of dehydration varied both according to the soybean variety and the applied treatment. In the first hour of dehydration, the percentage values of total water content ranged from 79.92 % (untreated Onix variety) to 92.79 % (Iris variety treated with Toprex), and after 24 hours, the values of total water content ranged from 25.69 % (Ziana variety treated with Moddus Evo) to 33.54 % (Iris variety treated with Toprex).

Key words: water, growth, drought, soybean

Soybean is a herbaceous crop belonging to the botanical family Fabaceae, subfamily *Fabioideae*, genus *Glycine L*. The most important and widely cultivated species of this plant is *Glycine max. L.*, also known as *Glycine hispida* (Moench.) Maxim (Mogârzan A., 2012).

The word "soia" (soybean) comes from the Chinese word "Shiang-yu," pronounced "shoyu" in Japanese. It's important to note that it originally referred not to the whole plant, but to soy sauce. The word evolved to "so-ya" in Japan and was subsequently adopted by the countries where the crop was introduced, eventually encompassing the entire plant (Dencescu S. *et al*, 1982).

In the early 1900s, the properties of soybean were discovered outside of Asia. Today, soybean is a globally valued and sought-after crop due to its ecological adaptability (Celeac V., Budac A., 2013).

Soybean is also referred to as the plant of the future, potentially capable of meeting the global protein demand. As such, soybean is cultivated for its seeds which are rich in protein (33.0 – 45%) and lipids (18 – 24.5%) (Roman G.V. *et al*, 2011).

Water is an indispensable component for the life of plants and plays a crucial physiological role. At the cellular level, it provides the optimal environment for vital biochemical reactions. In plants, water acts as a thermoregulator through its circulation within the plant organism and the process of transpiration. Additionally, water is involved in cell elongation, ensuring the normal volume of tissues and plant organs during the growth process (Jităreanu C.D., Toma L.D., 2007).

Reducing the water content in plants leads to the inhibition of the growth process, a decrease in the speed of assimilate translocation, and a reduction in the intensity of photosynthesis. Furthermore, by negatively influencing enzymatic activity, biochemical processes within the plant are affected (Burzo I., 2015).

Crop yield and quality are directly influenced by temperatures and precipitation. Initial studies on climate change effects on crops have focused on the impact of elevated carbon dioxide levels (CO_2), global average temperatures, precipitation, and nutrition on agricultural yield. Crops react differently to climate change as they

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are subjected to multiple stress factors that affect their growth, development, and productivity (John R.P., Mikhail A.S., 2005).

MATERIAL AND METHOD

The results presented in this study originate from the experimental field of A.R.D.S. Secuieni, Neamț (Agricultural Research and Development Station Secuieni, Neamț), from a bifactorial experiment aimed at determining the influence of growth regulators on the water regime of soybean plants. The experiment was bifactorial in nature, with Factor A represented by the Soybean Variety, and Factor B represented by the growth regulator. Both Factor A and Factor B had four levels, represented by the soybean varieties Eugen, Onix, Iris, and Ziana for Factor A, and the untreated control along with the growth regulators Moddus Evo, Ormet, and Toprex for Factor B.

In this study, four Romanian soybean varieties (Eugen, Onix, Iris TD, Ziana TD) creation of by A.R.D.S. Turda were utilized. All four varieties are early-maturing, belonging to the maturity group OO. Productivity and quality-wise, these varieties have a yield potential of over 4500 kg/ha, protein content exceeding 40%, and oil content surpassing 20%. Additionally, these varieties exhibit excellent resistance to lodging, shattering, and powdery mildew.

For the purposes of the proposed research, namely, determining the influence of growth regulators on the water regime of soybean plants, the four soybean varieties underwent treatments using 3 commercial products with specific growth regulator actions.

Moddus Evo is a product with a plant growth regulator action, containing 250 g/l Trinexapac-ethyl. When applied to growing crops, it helps produce shorter, stronger plants with improved root systems. It is predominantly absorbed through leaves and stems and is translocated to meristematic areas, where it inhibits internode elongation. (https://www.verdon.ro).

Ormet is a growth regulator containing 480 g/l Ethephon. This product is rapidly absorbed by plants and translocated to meristematic areas where it optimizes internode elongation, thus limiting the risk of lodging. It also results in stem thickening, increased leaf surface, and ease of harvest. (https://www.adama.com/romania/ro/plant protection products/growth regulators).

Toprex is a product that combines the protection of a fungicide with the benefits of a growth regulator. It contains two active substances, 125 g/l paclobutrazol (growth regulator) and 20 g/l difenoconazole (fungicide). The active substances are rapidly absorbed by plants and distributed acropetally in the xylem. The benefits of the product include optimizing plant height growth, healthy root system development for better plant stability, and crop uniformity. (https://www.adama.com/romania/ro/plant-protection products/fungicides/toprex).

The field layout for this experiment employed a subdivided plot design, with three replications. The soil type used was typical Cambic Phaeozem (Chernozem), characterized by a very good supply of phosphorus and potassium, a well-supplied active humus content and a low supply of nitrogen *(table 1)*.

Table 1

Characterization of the soil type on which the experiments were located

Characterization of the soil type	A.R.D.S. Secuieni phaeozem (chernozem) cambic	
	Value	Interpretation
pH_2O	7.29	neutral
Texture	40	muddy
$CaCO_3$ (%)	0.91	slightly chalky
Humus Content	2.3 %	well
Total Nitrogen Content (mg/kg)	9.4	poorly supplied with nitrogen
Phosphorus Content (mg/kg)	189	very well supplied with mobile phosphorus
Potassium Content (mg/kg)	304	very well supplied with mobile potassium

During the establishment of the experiment, all technological steps were followed. The difference was made by the treatments applied during soybean flowering (BBCH 51 - 55). Determinations regarding the water content of the plants were carried out seven days after the treatment application, by collecting five plants (leaf samples) from each variant in the field.

To highlight the influence of the applied treatments on the water content of the plants, the rate of leaf dehydration was monitored through hourly weighing for 4 hours and after 24 hours. Additionally, the dry matter content of the leaves was determined by chopping the plant material and drying it in an oven for 4 hours at a temperature of

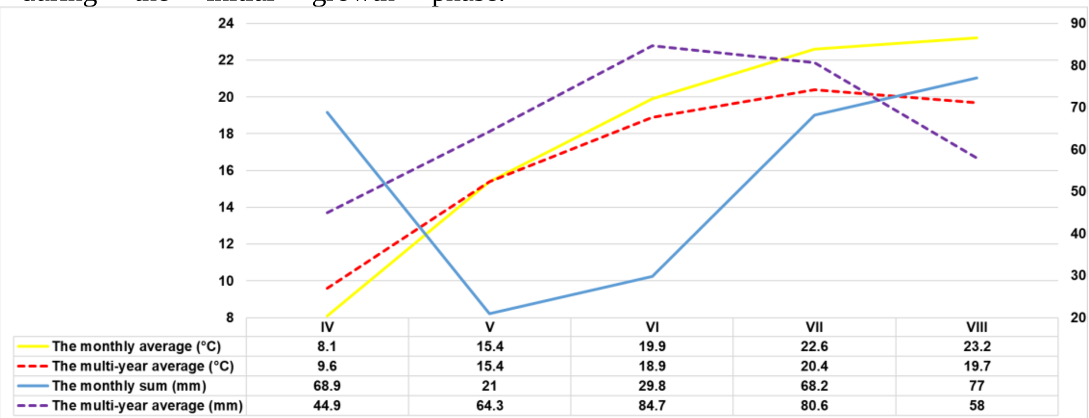
105 °C. Weighing of the leaves was done using an analytical balance.

RESULTS AND DISCUSSIONS

The agricultural year 2022-2023 was characterized as highly atypical for field crops, especially for soybeans, which experienced a vegetation period marked by high temperatures and severe drought conditions *(figure 1).*

The soybean crop exhibited uniform germination, thanks to the precipitation in April and the first decade of May. The crop developed rapidly during the initial growth phase. Unfortunately, the lack of precipitation in May and June slowed down the crop's growth, which also suffered due to the high temperatures during this period *(figure 1).*

Throughout the vegetation period of the soybean crop, the recorded precipitation was unevenly distributed, and their total sum was below the multi-year average. Analyzing the pluviometric characteristics of the vegetation period (as shown in *figure 1*), it is evident that it was exceptionally dry, with significant negative effects on the growth and development of the soybean plants.



	IV	V	VI	VII	VIII
The monthly average (°C)	8.1	15.4	19.9	22.6	23.2
The multi-year average (°C)	9.6	15.4	18.9	20.4	19.7
The monthly sum (mm)	68.9	21	29.8	68.2	77
The multi-year average (mm)	44.9	64.3	84.7	80.6	58

Figure 1 **Climate conditions recorded at A.R.D.S. Secuieni, 2023.**

At the onset of flowering, the relative air humidity ranged from 74 % to 83 %, which positively favored soybean fructification. During this period, the average temperatures varied between 19.4 °C and 24.9 °C. The maximum temperatures ranged from 23.4 °C to 33.8°C, while the minimum temperatures ranged from 14.0°C to 18.6°C. These temperatures negatively affected fructification, leading to flower abortion. In addition to the high temperatures recorded at the beginning of flowering, there was also a soil drought, with May and June being very dry. All of these factors had negative influences on the soybean plants. Consequently, the treatments were applied when the soybean plants were under significant stress (*figure 2).*

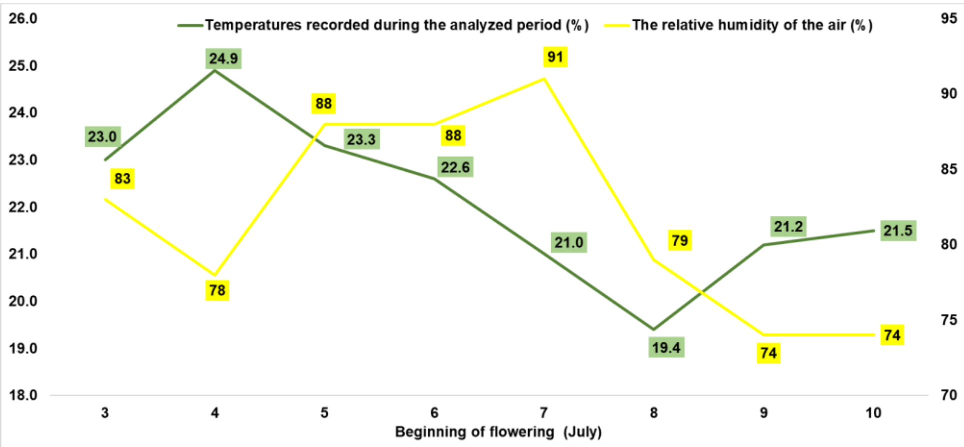


Figure 2 **Climate conditions recorded at the onset of soybean blooming (July)**

Leaf mass directly influences the amount of captured light energy by soybean, thus directly affecting photosynthesis, transpiration, and the plant's final yield. It is important to determine the effects of drought-induced stress and find solutions to mitigate it.

Regarding the results obtained during soybean blooming, it is observed from figures 3-6 that the dehydration rate in soybean varied significantly depending on the cultivated variety and the applied treatment.

For instance, in the case of the Eugen variety, in the untreated variant, a water content of 31.90 % was determined after 24 hours. In the first four hours, the dehydration rate per hour ranged between 6.16 % (4 hours) and 9.92 % (3 hours). After 24 hours, in the variants treated with growth regulators, the water content ranged from 27.59 % (Toprex) to 29.96 % (Ormet). The dehydration rate per hour varied between 6,3 % (4 hours) and 11,52 % (3 hours) in the variant treated with Moddus Evo, between 7.82 % (2 hours) and 11.26 % (3 hours) in the variant treated with Ormet, and between 4.83 % (4 hours) and 9.88 % (3 hours) in the variant treated with Toprex *(figure 3).*

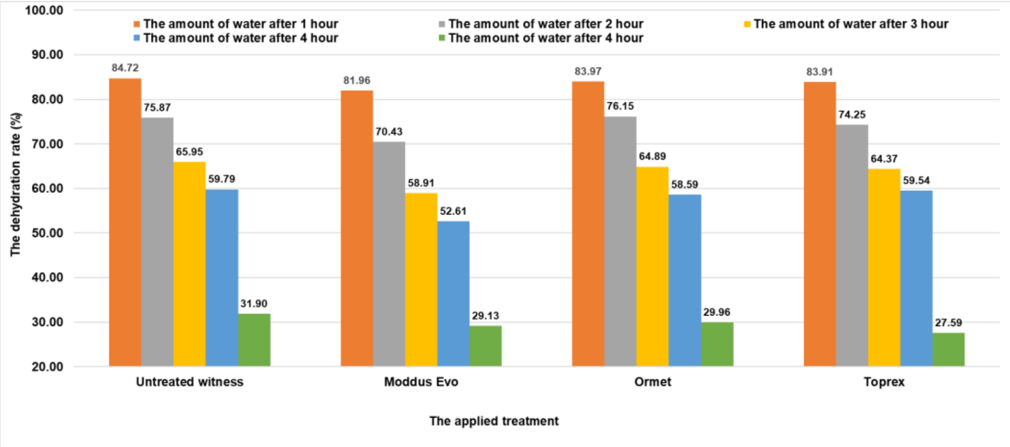


Figure 3 **Influence of treatment on the dehydration rate in the Eugen variety**

For the Onix variety, in the untreated variant, a water content of 26.64 % was determined after 24 hours, with the dehydration rate per hour ranging from 10.42 % (4 hours) to 13.13 % (3 hours) in the first four hours. In the variants where growth regulators were applied, the water content varied between 26.81 % (Ormet) and 27.81 % (Toprex) after 24 hours. The dehydration rate per hour ranged from 6.24 % (4 hours) to 13.36 % (2 hours) in the Moddus Evo treated variant, between 6.63 % (4 hours) and 12.62 % (3 hours) in the Ormet treated variant, and between 6.38 % (4 hours) and 15.05 % (2 hours) in the Toprex treated variant *(figure 4)*

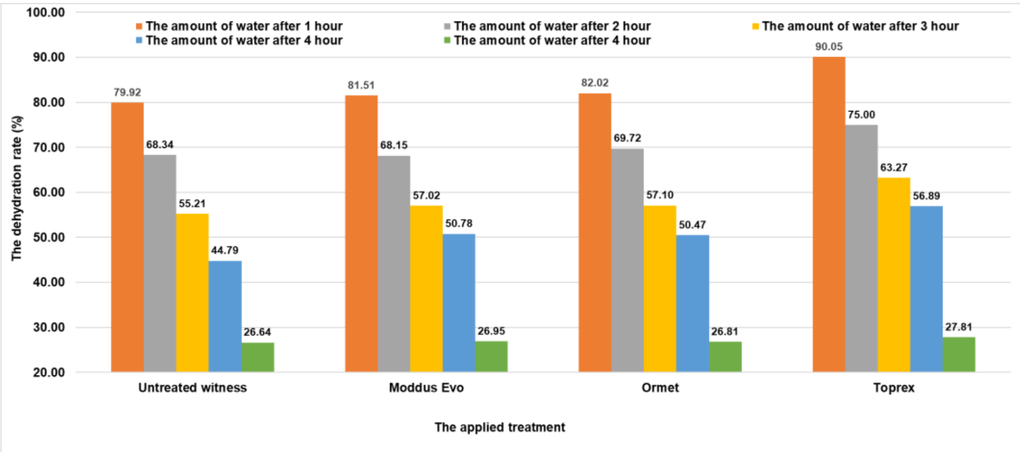


Figure 4 **Influence of treatment on the dehydration rate in the Onix variety**

For the Ziana variety, in the untreated variant, the water content was 27.07 % after 24 hours, with the dehydration rate per hour varying between 5.86 % (4 hours) and 14.55 % (2 hours) in the first four hours. In the variants where growth regulators were applied, the water content ranged between 25.69 % (Moddus Evo) and 28.41 % (Ormet) after 24 hours. The dehydration rate per hour varied between 6.42 % (4 hours) and 16.77 % (3 hours) in the Moddus Evo treated variant, between 5.51 % (4 hours) and 14.78 % (2 hours) in the Ormet treated variant, and between 5.71 % (4 hours) and 15.47 % (2 hours) in the Toprex treated variant *(figure 5).*

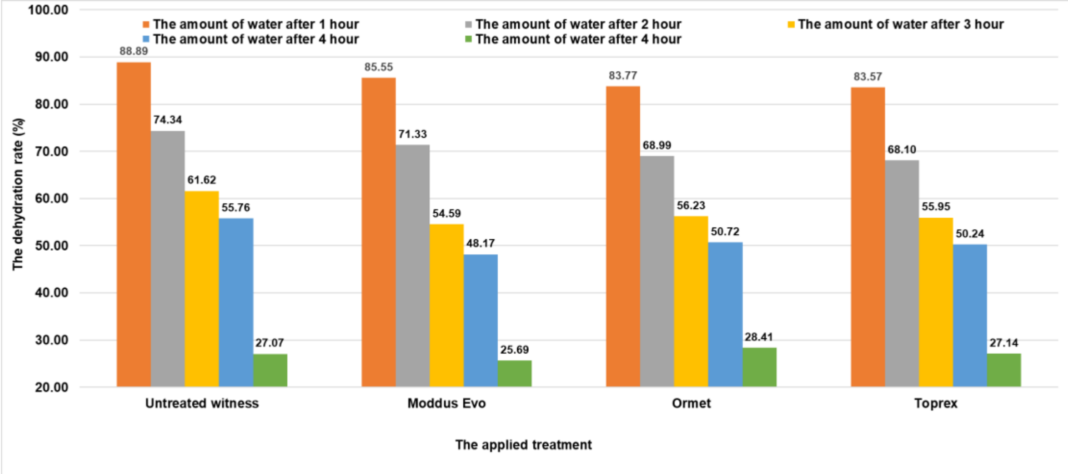


Figure 5 **Influence of treatment on the dehydration rate in the Ziana variety**

At the Iris variety, in the untreated version, a water content of 30.96 % was recorded after 24 hours. In the first four hours, the dehydration rate per hour ranged from 5.33 % (4 hours) to 10,4 % (2 hours). After 24 hours, in the versions treated with growth regulators, the water content ranged from 30.38 % (Ormet) to 33.54 % (Toprex). The dehydration rate per hour varied between 5.31 % (4 hours) and 11.33 % (2 hours) for the version treated with Moddus Evo, between 5.77 % (4 hours) and 13.08 % (2 hours) for the version treated with Ormet, and between 4.39 % (4 hours) and 11.29 % (2 hours) for the version treated with Toprex *(figure 6)*.

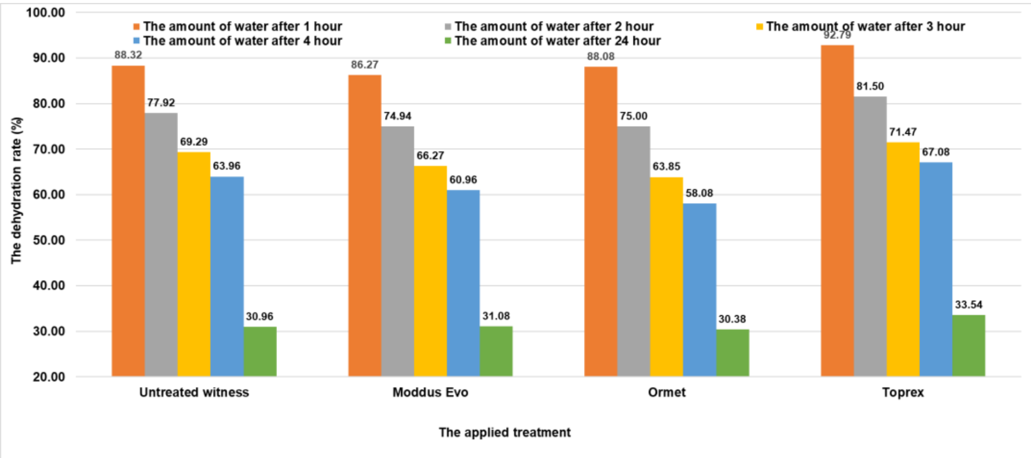


Figure 6 **Influence of treatment on the dehydration rate in the Iris variety**

The dry matter content also varied, both depending on the variety and the applied treatment. For the Eugen variety, it ranged from 18.70 % (Ormet) to 19.20 % (Toprex). It is worth noting that in the untreated variant seeded with the Eugen variety, the dry matter content was high, at 19.14% *(figure 6).*

In the variant seeded with the Onix variety, the dry matter content varied between 17.93% (Toprex) and 19.25 % (untreated control), while in the variant seeded with the Ziana variety, the values of dry matter content ranged from 18.35 % (untreated control) to 19.81 % (Ormet). In the variant seeded with the Iris variety, the variation in dry matter content was between 18.35 % (Moddus Evo) and 22.63 % (Toprex) *(figure 7).*

Analyzing the results obtained for the interaction between the studied factors (variety x growth regulator), it can be observed that the slowest dehydration rate was recorded in the variant sown with the Iris variety, to which the commercial product Toprex was applied. Its value after 24 hours was 66.46 %, with a water content of 33.54 N% *(figure 6).*

Additionally, this variant also had the highest dry matter content, which was 22.63 % *(figure 7).* Considering that this variant stands out for its high dry matter content, it provides us with the premise that a larger proportion of the total plant mass is represented by solid substances, including proteinaceous substances.

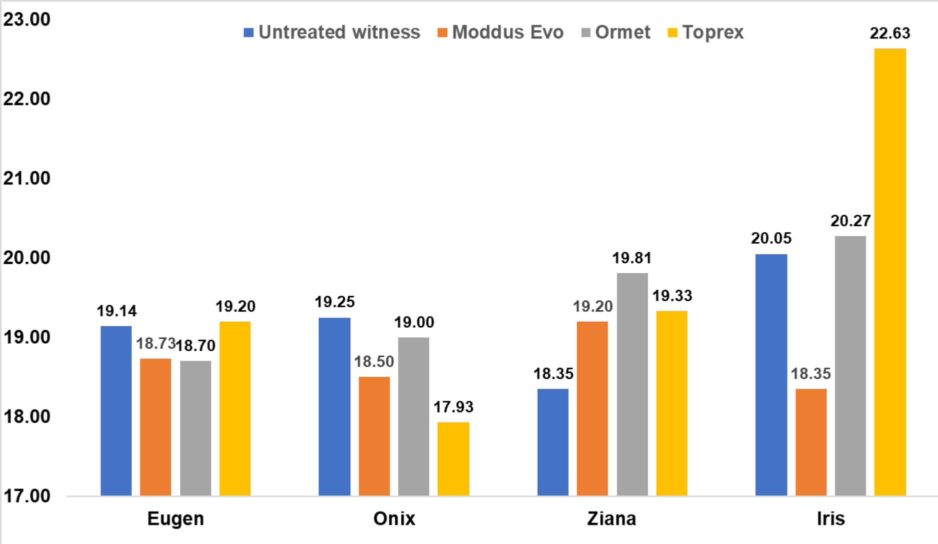


Figure 7 **The Influence of treatment on soybean dry matter content**

CONCLUSIONS

Soybean is a globally esteemed and sought-after crop due to its ecological adaptability and its seeds, which are rich in proteins and lipids.

Water is an indispensable component for plant life and plays an essential physiological role. However, the water content of plants is directly influenced by climatic conditions.

The water content of the plants varied both depending on the variety and the applied treatment.

The lowest dehydration rate was recorded in the Iris variety. The water content determined after the first hour ranged from 86.27 % (Moddus Evo) to 92.79 % (Toprex), and after 24 hours, it fluctuated between 30.38 % (Ormet) and 33.54 % (Toprex).

Additionally, the highest dry matter content was recorded in the Iris variety, with values ranging from 18.35 % (Moddus Evo) to 22.36 % (Toprex).

The slowest dehydration rate was observed in the variant sown with the Iris variety, to which the commercial product Toprex was applied.

REFERENCES

Burzo I., 2015 – *Abiotic stress in crop plants*. Elisavaros Publishing House, Bucharest.

Celeac V., Budac A., 2013 – *Soybean culture*. I.S.F.E.P, Central Printing House Chisinau, Moldova.

Dencescu S., Miclea E., Butică A., 1982 – *Soybean culture*. Ceres Publishing House, Bucharest.

Jităreanu C. D., Toma L. D., 2007 – *Plant physiology*. Ion Ionescu from Brad Puplishing House, Iasi.

John R.P., Mikhail A.S., 2005 – *Crop responses to climatic variation.* Philosophical transactions of the royal society B, Vol. 360, Issue 1463.

Mogârzan A., 2012 – *Plant engineering*. Editura Ion Ionescu de la Brad, Iași.

Roman V. Gh., Tabără V., Robu T., Pîrșan P., Axinte M., Ștefan M., 2011 – *Plant engineering volume I.* Universal Publising House, Bucharest.

***https://www.verdon.ro/inhibitors-regulators/growth-regulators -moddus-evo-1-liter.html)

***https://www.adama.com/romania/ro/ products-for-plant-protection/regulators-growth/ormet?gclid=EAIaIQobChMIo_zp7qHKgQMV8VBBAh0xCQF2EAAYASAAEgL_lvD_BwE

***https://www.adama.com/romania/ro/products-for-plant-protection/fungicides/toprex).