Agronomy Research **19**(2), 394–407, 2021
https://doi.org/10.15159/AR.21.080

Effect of superabsorbent on soil moisture, productivity and some physiological and biochemical characteristics of basil

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Received: February 8th, 2021; Accepted: May 5th, 2021; Published: May 14th, 2021

Abstract. The study was carried out in 2019–2020, in the conditions of the Right-Bank Forest-Steppe of Ukraine. The results on the influence of absorbents in gel and powder forms on the productivity of basil plants (*Ocimum basilicum* L.) are presented. For research were used field, laboratory, statistical and calculation-analytical methods. Absorbent in the form of a gel was used while transplanting: dip the roots of the plant in the solution and then transplant in the field. Absorbent in the form of a powder - 5 kg ha^{-1}, application of the absorbent into the soil layer 20–25 cm^{-1}. Absorbents contributed to a slight decrease of sugar content (-0.86–2.68% in the cultivar of Badioryi, -1.48–2.35% in the cultivar of Rutan), significantly decrease ascorbic acid (-8.6–20.1%) and content of the essential oil (8.0–19.4%) and indirectly increased essential oil yield by increasing fresh weight yield in both varieties. The activity of APX, CAT, SOD, tended to decrease in all variants of the experiment, regardless of the form of the absorbent. APX (-12.8–35.1%), CAT (-10.9–22.0%), SOD (-11.9–17.0%). Higher yields were observed in the version with the introduction of the absorbent in the form of a gel. Thus, the yield of the cultivars of Badioryi and Rutan exceeded the control by 52.67 and 50.05%, in accordance. The productivity of basil is increased with the use of superabsorbent polymers. This practice can be recommended to agricultural producers who grow vegetables, in particular, basil in areas of unstable or insufficient moisture.

Key words: antioxidant activity, *Ocimum basilicum,* chlorophyll, yield.

INTRODUCTION

The stability of the production of vegetable greens in the forest-steppe of Ukraine depends mainly on weather conditions. The main factors limiting the productivity of vegetables are climate aridity, which has increased in recent years.

Optimization of the water regime of soils, preservation of moisture reserves in it, leveling of moisture deficit are urgent problems of agrocenoses. Ensuring optimal soil moisture is one of the main conditions for increasing fertility, their sanitary protection functions.

Application of hydrogels consists in rough powders of polyacrylamide or potassium polyacrylatematrix sold with a huge range of names (Plant-Gel, Super Crystals, Water-Gel Crystals) and used as long term reservoir of water for plant growth in gardening, and industrial horticulture (Chalker-Scott, 2015)

Superabsorbent polymers are hydrophilic polymer networks that have the potential to absorb and hold a large amount of water and aqueous solution sintheirn et work Zohuriaan-Mehr &Kabiri (2008), Milani et al. (2017), Das et al. (2020). 'As a class of material, hydrogels are unique, they consist of a self-supporting, water-swollen three-dimensional (3D) viscoelastic network which permits the diffusion and attachment of molecules and cells' Chirani et al. (2016).

The hydrogels play an important role in agriculture Dehkordi (2017). Over the last decade, hydrogels have been widely used to improve water penetration for plants, by increasing water retention properties, the use of hydrogel polymers can be an effective means of improving water and fertilizer efficiency Dehkordi et al. (2013), Skrzypczak et al. (2020) it can absorb and store water many times more from its own volume and perform the function of reservoirs with water and increase the efficiency of irrigation, as well as superabsorbent polymers improve some physical properties of the soil.

The hydrogel polymer was developed as a retarder to reduce groundwater losses and increase crop yields Hüttermann et al. (1999); Bahram et al. (2016), Ovalesha et al. (2017).

The hydrogel products can be classified as: Based on source (Zhao et al., 2013; Sandhya et al., 2021):

Natural hydrogels;

Synthetic hydrogels;

Semi-synthetic hydrogels.

Synthetic hydrogels based on acrylates and acrylamides show high mechanical strength and the potential to absorb significant quantities of water. Due to the problem of their biodegradability, they are being attempted to replace with biopolymers such as alginate, agar, cellulose, chitosan, and starch (Skrzypczak et al., 2020)

Hydrogels may be obtained from natural sources or they can be prepared synthetically. Alginate, Xanthan, Dextran, Pullulan, Hyaluronic acid, Guar gum, Okra gum, and Locust gum, Gellan, Xyloglucan, Pectin and Scleroglucan are some of the examples of natural polymers capable of forming hydrogels. Some of the examples of synthetic polymeric gelators are Poly (vinylalcohol), Polymethacrylic acid (PMAA), Polyacrylic Acid (PAA) Poly N-vinylpyrrolidone) PVP), polyethyleneglycol diacryl ate/dimethacrylate PEGDA/PEGDMA), Polyethyleneglycol acrylate/methacrylate (PEGA/PEGMA), and Poly (styrene) (PS) (Saini, 2016).

A productive life of hydrogels of 5 years that is, the effect of the absorbent after application to the soil is observed for 5 years. The recommended doses vary from 5 to 25 kg ha-1, depending on the type of soil, crop and climate, according to the manufacturer (SNF Inc., 2011; Pande, 2017). In addition to the effect of water retention in the soil, these products improve aeration and maintain temperatures that promote better plant development, with the consequent effect on yield, as has been shown experimentally in crops such as Glycine max (Galeş et al., 2012), *Apium graveolens* (Kosterna et al., 2012), potato (Faried et al., 2014; Starovoitova et al., 2020), *Vigna Unguiculata* L. (Lopes et al., 2017), *Pisum sativum* (Norodinvand et al., 2019), wheat (Shaikh et al., 2020). Söylemez et al. (2020) it has been determined that total yield, total fruit number, average fruit weight, root, shoot and leaf dry weights, plant height, stem diameter and chlorophyll content generally increased with use of waterpad, but these increases were statistically insignificant.

The hydrogel polymers are used as a water-retaining material in arid, semi-arid or in regions with unstable rainfall Montesano et al. (2015). Moreover, previous studies indicate a good ability of the hydrogel polymer to increase water retention, which helps reduce water stress in plants and ensure high plant productivity, which leads to increased growth and yield Belen-Hinojosa et al. (2004). The research should focus to reduce utilization of water in agricultural sector as it uses a large amount of water. This problem can be minimized by the use of hydrogels (Shubhadarshi & Kukreja, 2020).

Therefore, the main purpose of this study was to evaluate the effect and effectiveness of various forms of superabsorbents on plant growth, chlorophyll content, activity of antioxidant enzymes and basil productivity.

MATERIALS AND METHODS

The research of the influence of different forms of superabsorbent was carried out in 2019–2020 on the experimental field of the Department of Vegetable Growing of Uman National University of Horticulture (Right-Bank Forest Steppe of Ukraine) in accordance with national methods Bondarenko & Yakovenko (2001), Ulianych et al. (2019, 2020).

The soil was black, puddle, heavy loam with a well developed humus horizon (about 2.9% of humus) in the deep of 40–45 cm^{-1}. Soil pH was determined in water (soil water ratio 1:1). Electrical conductivity (ECe) of the soil suspension was measured using the conductivity meter. The P, K were determined by AB-DTPA method Ryan et al. (2001). Chemical properties of soil: organic carbon - 2.2%, pH 6.0 -6.2, P - 102 mg kg^{-1}, K - 123 mg kg^{-1}, NO_3-N - 64 mg kg^{-1}.

Planting was carried out by the scheme of 50×30 cm. The total area for the experiment was 400 m^2, for the plot it was 100 m^2, and for the sampling - 10 m^2. The experiment was performed as a Factorial Randomized Block Design with four replications.

The two-factor experiment consisted of the use of superabsorbent of the company 'Maxi Marin' in the form of gel (anionic polyacrylamide copolymer) and powder with granulometry < 0.5 mm (cationic polyacrylamide copolymer).

Application methods. Superabsorbents were applied before planting seedlings to a depth of 15 cm. Absorbent in the form of a gel was used while transplanting: Thoroughly mix 2 g (or according to recommended rate) of hydrogel per litre of water to prepare a free-flowing solution; allow it to settle for half an hour. Dip the roots of the plant in the solution and then transplant in the field. Absorbent in the form of a powder - 5 kg ha^{-1} before planting seedlings, locally in the furrows (according to the manufacturer's recommendations), application of the absorbent into the soil layer 20–25 cm^{-1}.

Biometric research. The leaf length and width, leaf blade area and total leaf area per plant on the 60th day after planting (DAP) (BBCH 55) were determined; the plant height and the number of leaves per plant were calculated, and the leaf blade area was determined by a calculated (linear) method, using the parameters of length and width of the leaf by the formula:

$$Sn = 0.74 \times ab \quad (1)$$

where Sn – single leaf area, cm²; a – the largest leaf width, cm; b – leaf length, cm; 0.74 is the leaf configuration coefficient.

We studied the effect of various forms of superabsorbent on the basil cultivars (enzymes activity, productivity of plants, pigments contents in leaf, vitamin C). All analyzes were performed in three replicates.

Plant material. Basil (*Ocimum basilicum* L.) cv. Badioryi and Rutan.

Determination of chlorophylls. The plant material was washed with distilled water and air-dried in a shady, well-ventilated room at the temperature of 22–25 °C. Then, 0.10–0.05 g of the sample was weighed and triturated with 5 mL of the solvent (ethanol) for 15 min. The obtained suspension was filtered into a volumetric flask (capacity of 10 mL) and supplemented with ethanol. Concentrations ($\mu g\ mL^{-1}$) of chlorophylls a and b, were determined using equations published by and Lichtenthaler & Buschmann (2001):

$$\text{Chlorophyll a} = 13.36A_{664.1} - 5.19A_{648.6} \quad (2)$$

$$\text{Chlorophyll b} = 27.43A_{648.6} - 8.12A_{664.1} \quad (3)$$

Activity measurements of antioxidant enzymes

A sample of 0.5 g^{-1} of fresh sweet basil seedling leaves was macerated in liquid nitrogen to obtain the extract for measurements, as proposed by Waterhouse (2002). The method used to measure antioxidant activity was based on the scavenging activity of the 2,2-diphenyl-1-picryl-hydrazyl radical (DPPH, 60 µM), as proposed by Rufino et al. (2009). The absorbance was measured at 515 nm^{-1} using a spectrophotometer (UV-VIS Beckman 640 B). The readings were monitored every 30 min to a total of four readings, while the absorbance reduction was observed until stabilization. All measurements were performed in triplicate. The results were expressed as the percentage of free radical scavenging activity (% FRS), according to the equation:

$$aa = [(A_{control} - A_{test})/A_{control}] \times 100, \quad (4)$$

where aa is the antioxidant activity (%); $A_{control}$ is the absorbance of the control solution, and A_{test} is the absorbance of the extract samples.

The enzymatic extract was obtained by maceration of 200 mg of fresh leaf tissue in liquid nitrogen, with the addition of 1.5 mL of 400 mm potassium phosphate extraction buffer (pH 7.8), 1.0 mm EDTA, and 200 mm^{-1} ascorbic acid. The suspension was centrifuged at 12,000 rpm for 15 min^{-1} at 40 °C and the supernatant collected Bonacina et al. (2017).

Superoxide dismutase (SOD, EC 1.15.1.1) activity was measured by its ability to inhibit the photochemical reduction of nitroblue tetrazolium, as described by Giannopolitis & Ries (1977). The absorbance of the reaction mixture was read at 560 nm^{-1}, and one unit of SOD activity (UA) was defined as the amount of enzyme required to cause 50% inhibition of the nitroblue tetrazolium photoreduction rate. The results are expressed as UA mg^{-1} fresh weight (FW) min^{-1}.

Catalase (CAT, EC 1.11.1.6) activity was determined, as described by Havir & Mchale (1987), by the H_2O_2 consumption, which was monitored by reading the absorbance at 240 nm at the moment of H_2O_2 addition and 1 min^{-1} later. The difference in absorbance was divided by the H_2O_2 molar extinction coefficient (36 M^{-1} cm^{-1}) Anderson et al. (1995). CAT activity was expressed in mmol H_2O_2 g^{-1} FW min^{-1}.

Ascorbate peroxidase (APX, EC 1.11.1.11) activity was detected according to the method described previously by Nakano & Asada (1981). The absorbance was read at 290 nm 1 min^{-1} after H_2O_2 was added to the reaction solution. The APX activity was quantified using a molar extinction coefficient of 2.8 mm^{-1} cm^{-1}. The results were expressed in mmol ascorbate g^{-1} FW min^{-1}. All enzymes were evaluated using 96-well flat-bottomed ELISA plates. In all assays, three technical replicates and three biological replicates were used. The absorbance was read using a spectrophotometer (UV-VIS Spectra Max Plus®) with the Soft Max Pro program, version 6.5.1.

Dry matter (%). The average dry matter weight (g^{-1}) of leafs after curing were measured by drying 10 randomly sampled leafs in an oven with a forced hot air circulation at 70 °C until a constant weight was obtained. The percentage of leafs dry matter was calculated by taking the ratio of the dry weight to the fresh weight of the sampled leafs and multiplying it by 100.

Extraction of basil essential oils. A sample (10 g) of air dried basil leaf were used for essential oil distillation. Basil oil was extracted by hydrodistillation using an Electrothermal type (UK) apparatus. The duration of this procedure was 2 hours. The yield (v/w) of the obtained essential oil was expressed as a percentage of absolute dry weight (Grytsaenko et al., 2003).

Analysis of vitamin C. Lyophilized samples (each 0.2 g^{-1}) were ground and added to 30 mL^{-1} of 3% metaphosphoric acid solution and homogenized at 11,000 rpm for 2 min^{-1} using a T25 basic ULTRA–TURRAX homogenizer (IKAWerke GmbH & Co. KG, Staufen, Germany). The volume was made up to 50 mL with 3% metaphosphoric acid solution. The extract (2 mL^{-1}) was centrifuged at 12,000 rpm for 3 min^{-1}, and the supernatant filtered through a 0.45 lm polyvinylidene difluoride (PVDF) membrane filter (Whatman I nternational Ltd., Maidstone, UK). All samples were immediately analyzed using an HPLC system, equipped with a PU (2089 pump), an AS (2057 auto injector), and a MD (2010 UV) vis variable wavelength detector (JASCO Corp., Tokyo, Japan). Separation was carried out in a Crest Pak C18S column (15,094.6 mm, i. d., 5 lm, JASCO Corp.), and the isocratic elution was carried out with 0.1% trifluoroacetic acid in distilled water as a mobile phase for 15 min^{-1} (flow rate 0.8 mL^{-1} min^{-1}). The peak was read at 254 nm using an UV detector and quantification was determined via external calibration against ascorbic acid.

Soil moisture. The research was conducted on the chernozem of clay granulometric composition. The study of the productive moisture reserves in was conducted on six sample plots in three replicates, laid on the levelled area of arable land. The moisture content was determined by the thermogravimetric method, the density of the composition by Kachynski method:

$$W_{spm} = W_t - W_{pm} \quad (5)$$

where W_{spm} – stock of productive moisture (mm); W_t – total water supply in the soil at the time of sampling, mm; W_{pm} – water supply in the soil, which accords to the wilting point, mm.

Total water supply in the soil at the time of sampling. was determined by thermostatic weight method according to the formula:

$$W_t, \% = \frac{A - B}{B - C} \times 100 \qquad (6)$$

where A – the mass of the box with raw soil, g; A – weight of the box with dry soil, g; C – the mass of the empty box, g.

The weather conditions in the years of research. According to the Uman meteorological station, hydrometeorological conditions in 2019 were characterized by slightly less precipitation compared to long-term averages. The amount of precipitation for this period in 2020 was much higher than in 2019. Most of them fell in June, which allowed the plants to form better leaf mass (Fig. 1).

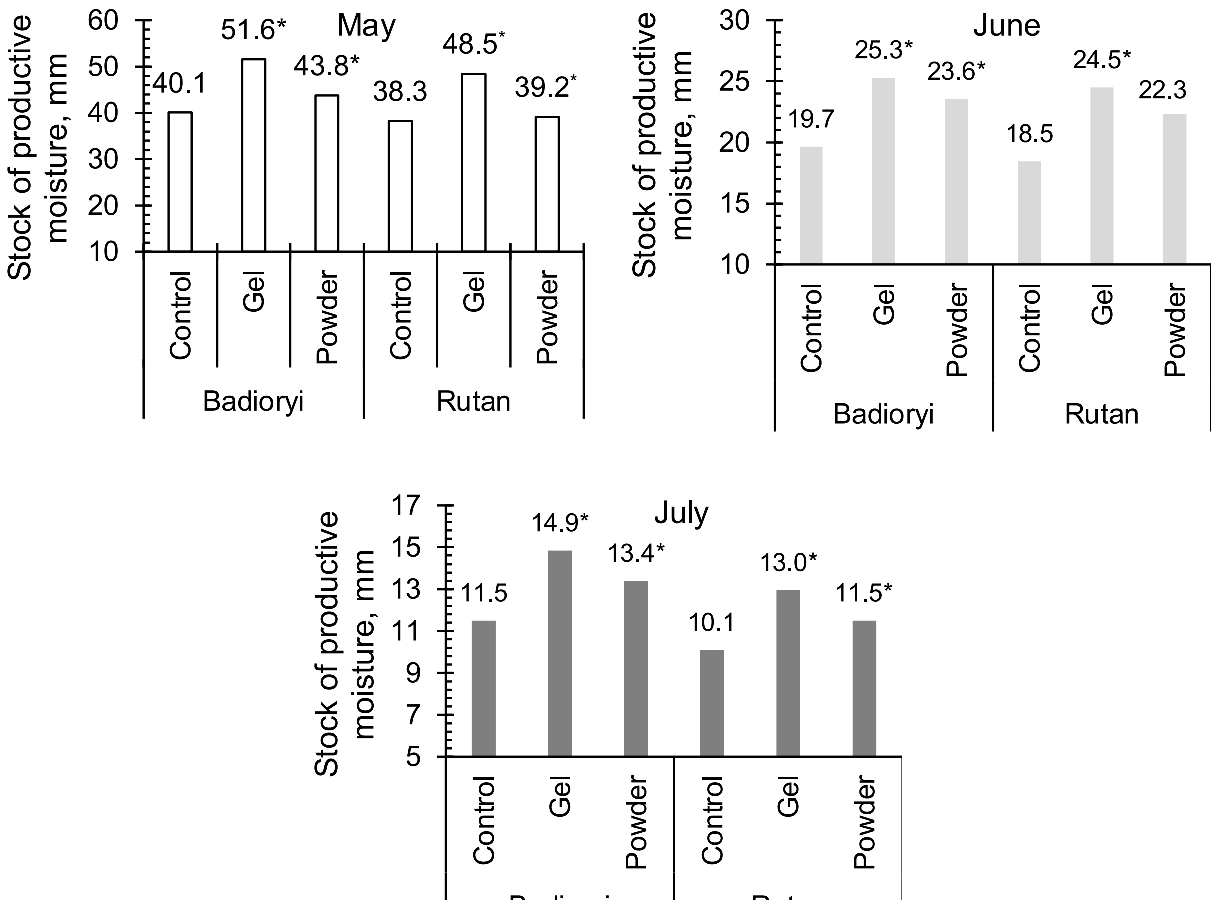

Figure 1. Dynamics of stock of productive moisture (mm) in the root zone (in the soil layer 0–30 cm) of basil cultivars vs. various form of superabsorbent.

Results of statistical processing	May	June	Jule
$LSD_{0.05}$ A	1.51	0.57	0.29
B	1.85	0.70	0.35
A×B	2.62	0.99	0.50

* show significance at the $P \leq 0.05$ probability levels.

The air temperature in 2019–2020 at the time of planting was slightly higher than the perennial one, which had a positive effect on the development of true basil plants (Table 1).

Table 1. The weather conditions during the growing season of basil (2019–2020)

Month	Precipitation, mm			Temperature °C		
	2019	2020	Average for many years	2019	2020	Average for many years
May	35.6	101.0	55.0	17.0	12.5	14.6
July	69.8	70.4	87.0	23.4	20.9	17.6
June	33.8	21.4	87.0	20.0	21.6	19.0
August	19.2	17.1	59.0	20.7	21.2	18.2
September	30.6	27.4	43.0	15.6	17.8	13.6

Statistical analysis. For the food and chemical composition, three samples were analyzes were performed in three replicates. The results were expressed as averages. The antioxidant activity, and chemical composition were analyzed using analysis of variance, with $P \leq 0.01$, for yield, weight of plant and stock of productive moisture $P \leq 0.05$ using statistical analysis program (SAS) v. 9.1.3.

RESULTS AND DISCUSSION

Since the main root mass of basil plants is located in the arable soil layer (0–30 cm), the productivity of this crop largely depends on its moisture content. In 2020, the reserves of productive moisture accumulated during the winter-spring period were higher than in 2019 due to heavy rainfall in May. The superabsorbent in the form of a gel helped to increase the reserves of productive moisture. On average over two years, the application of the gel increased this indicator relative to control by 27–29% in May; 25–37% in June; 28–29% in July. The application of the powder was much lower. The inter-varietal difference in moisture reserves was also revealed. The soil in the variants with the Badioryi cultivar was characterized by more reserves of moisture, which indicates its lower need for water and, accordingly, higher drought resistance. (Fig. 1).

Similar results are reported by Godunova et al. (2014) in studies with winter wheat and different hydrogel norms and Revenko & Agafonov (2018) in studies with soybeans and winter wheat, where productive moisture reserves increased significantly compared to controls.

The plant growth and the leaf area formation (Table 2). The absorbent in the form of a gel contributed to a significant increase in the height of plants of the cultivars of Badioryi and Rutan (+ 10.71 and 8.45% to control). The use of the absorbent in the form of a gel had a more positive effect on the increase of the diameter of the basil plant bush of both studied varieties (+ 16.14 and 14.10% to control). The absorbent in the form of a gel contributed to a significant increase in the number of leaves on plants of the cultivars of Badioryi and Rutan (+ 8.76 and 5.96% to control).

The use of the absorbent in the form of a gel contributed to a significant increase in the number of leaves on the plant (+ 8.76% in the cultivar of Badioryi and 5.96% in the cultivar of Rutan), the absorbent in the form of powder was less effective and caused a slight increase (+ 3.59 and 1.58% in accordance) of this indicator in both varieties. Plant height and number of leaves was increased due to high retention of moisture in soil and nutrients availability in the root zone of the crop, where it might have helped to enhance the activity of cell, causing increment in plant height and number of leaves per plant. The result is in conformity with the result of Al-Harbi et al. (1999) in cucumber.

Determination of the basil leaf area showed that it significantly increases with the use of the absorbent in the form of a gel (+ 7.26% in the cultivar of Badioryi, + 8.20% in the cultivar of Rutan).

Table 2. Plant growth and leaf area of the basil cultivars vs. various forms of superabsorbent (2019–2020), (BBCH 55)

Cultivar (factor A)	Super-absorbent (factor B)	Plant height, cm	Plant diameter, cm	Number of branches per plants, pcs.	Number of leaves, pcs.	Leaf area, cm²
Badioryi	Control	40.68	37.08	10.01	185.06	25.24
	Gel	45.04 ^{ns}	43.06*	10.53*	201.27 ^{ns}	31.00*
	Powder	42.43 ^{ns}	40.51 ^{ns}	10.41 ^{ns}	192.28 ^{ns}	27.40*
Rutan	Control	40.90	37.48	6.73	186.04	17.37
	Gel	44.35*	42.76*	7.73*	197.13 ^{ns}	22.34*
	Powder	42.09 ^{ns}	40.35 ^{ns}	7.64*	188.98 ^{ns}	19.54*
	$LSD_{0.05}$ A	1.12	1.40	0.24	5.54	0.52
	B	1.38	1.71	0.30	6.78	0.64
	A×B	1.95	2.43	0.42	9.59	0.90
	CV%	4.2	6.3	18.8	3.3	21.3

* show significance at the $P \leq 0.05$ probability levels.

Biochemical parameters (Table 3). In the control variants, the dry matter content in the in the cultivars of Badioryi and Rutan was 8.88 and 9.23%, in accordance, that is the use of absorbents in the cultivation technology causes an increase of yield, but the dry matter content is decreased.

Table 3. Biochemical parameters of the basil cultivars vs. various forms of superabsorbent (2019–2020), (BBCH 55)

Cultivar (factor A)	Super-absorbent (factor B)	Total sugar, mg 100 g^{-1} FW	Dry matter, %	L-ascorbic acid, mg 100 g^{-1} FW	Essential oil, %	Essential oil yield, kg ha^{-1}
Badioryi	Control	9.10	8.88	13.17	1.09	14,25
	Gel	9.02 ^{ns}	8.71 ^{ns}	10.51 ^{ns}	0.99*	17,02*
	Powder	8.86 ^{ns}	8.76 ^{ns}	12.26*	1.01*	15,39*
Rutan	Control	18.66	9.23	15.76	1.51	13,94
	Gel	18.38*	8.98 ^{ns}	12.65*	1.31*	16,52*
	Powder	18.22*	9.07 ^{ns}	14.41*	1.35*	15,24*
	$LSD_{0.01}$ A	0.51	0.36	0.60	0.05	0.65
	B	0.63	0.44	0.74	0.06	0.80
	A×B	0.89	0.62	1.03	0.09	1.13
	CV%	37.7	2.2	13.8	17.4	7.9

* show significance at the $P \leq 0.01$ probability levels.

The use of absorbents caused a slight decrease in sugar content, but the difference between the varieties was very significant: the cultivar of Badioryi - 8.86–9.10 mg 100 g^{-1} FW, the cultivar of Rutan - 18.22–18.66 mg 100 g^{-1} FW. The content of ascorbic acid, regardless of the form of the absorbent decreased significantly (6.9–20.1% in the cultivar of Badioryi and 8.6–19.7% in the cultivar of Rutan) in all variants of the experiment, but the use of the absorbent in powder form contributed to its largest and less decreased significantly content.

It has been suggested that under stress a higher density of oil glands due to the reduction in leaf area results in an elevated amount of oil accumulation. Studies on the effects of irrigation, which indicate a decrease in the content of essential oil in other crops with optimal and excessive moisture: Oregano (Virga et al., 2020), *Ocimum spp.* (Khalid, 2006), *Salvia officinalis* (Bettaieb et al., 2009).

In our study, growth parameters of basil improved after the use of water preservative compounds in soil and indirectly increased essential oil yield by increasing fresh weight yield.

The absorbent in the form of a gel contributed to a significant increase in the yield of the essential oil in both varieties. The use of the absorbent in powder form caused a less significantly increase of yield (8.00–9.33%) and absorbent in the form of a gel caused a significantly increase of yield (18.51–19.44%) of cultivar Badioryi and Rutan in the yield of the essential oil per unit of the area. The results of our research are similar to those obtained Shi et al. (2010), Kalamartzis et al. (2020), Beigi et al. (2020) reported about increased essential oil yield by increasing water availability in soil.

The activity of antioxidant enzymes and the pigment complex of leaves (Table 4). The activity of APX, CAT, SOD, tended to decrease in all variants of the experiment, regardless of the form of the absorbent.

The studied cultivars had significantly lower activity of APX and SOD (-12.84–24.13% APX and 11.85–11.97% SOD - in the cultivar of Badioryi - 21.15–35.12% APX and 16.01–16.99% SOD - in the cultivar of Rutan), but the activity of CAT had insignificant reduction of this indicator for both cultivars in all variants of the experiment (-10.89–18.43% - in the cultivar of Badioryi and 13.11–21.95% in the cultivar of Rutan).

Table 4. Antioxidant enzyme activity in leaves and leaf's total chlorophyll (*a* + *b*) content of the basil cultivars vs. various form of superabsorbent (2019–2020), (BBCH 55)

Cultivar (factor A)	Super-absorbent (factor B)	APX (mM ascorbic acid g^{-1} FW min^{-1})	CAT (mM H_2O_2 g^{-1} FW min^{-1})	SOD (U SOD mg^{-1} FW min^{-1})	Chlorophyll content, mg g^{-1} FW		
					a	*b*	∑ of chlorophyll
Badioryi	Control	0.23	0.40	74.75	1.05	0.38	1.43
	Gel	0.17*	0.32*	65.90*	1.29*	0.45*	1.74*
	Powder	0.20*	0.35*	65.80*	1.23*	0.38ns	1.61*
Rutan	Control	0.15	0.33	67.75	0.99	0.43	1.43
	Gel	0.10ns	0.26*	56.23ns	1.23*	0.52*	1.75*
	Powder	0.12*	0.29*	56.90ns	1.09*	0.48*	1.57*
	$LSD_{0.01}$ A	0.007	0.013	2.506	0.05	0.046	0.053
	B	0.010	0.016	3.069	0.06	0.056	0.070
	A×B	0.013	0.022	4.341	0.09	0.079	0.093
	CV%	30.1	15.1	10.9	10.3	12.3	8.9

* show significance at the $P \leq 0.01$ probability levels.

The obtained results indicate that the highest physiological activity is shown by SOD, where the activity of the antioxidant complex is significantly higher both against control and against other experimental options. The results of this study showed that increasing the activity of antioxidant enzymes in control variants of basil cultivars indicates their resistance to the drought.

The use of absorbents helped to increase the content of chlorophyll a + b, but with the use of the absorbent in the form of a gel, the increase was most significant to control (+ 21.31% in the cultivar of Badioryi, 22.51% in the cultivar of Rutan). The absorbent in the form of powder also contributed to a significant increase in the concentration of chlorophyll a + b of an average by 12.45% in the cultivar of Badioryi and by 10.29% in the variety Rutan. The inter-varietal difference according to this indicator was insignificant: the cultivar of Badioryi accumulated 1.43–1.74%, the cultivar of Rutan - 1.43–1.75% of dry matter.

Mass and yield of plants (Fig. 2). The results of the study indicated a significant effect of absorbents on the weight change of basil plants, regardless of the form of the absorbent in all variants of the experiment. The application of the absorbent in the form of a gel was more effective (+ 23.73 g^{-1} in the cultivar of Badioryi and 19.24 g^{-1} in the cultivar of Rutan). The absorbent in a powder form also caused a significant increase (+ 12.99 and 11.75 g^{-1}, respectively). of this indicator in both cultivars.

The yield, is the most important indicator of the effectiveness of cultivation technology. The use of absorbent of Maxi Marin in the form of granules increased the yield of basil of the cultivar of Badioryi by 2.89 and the cultivar of Rutan by 2.4 t ha^{-1} relatively to the control.

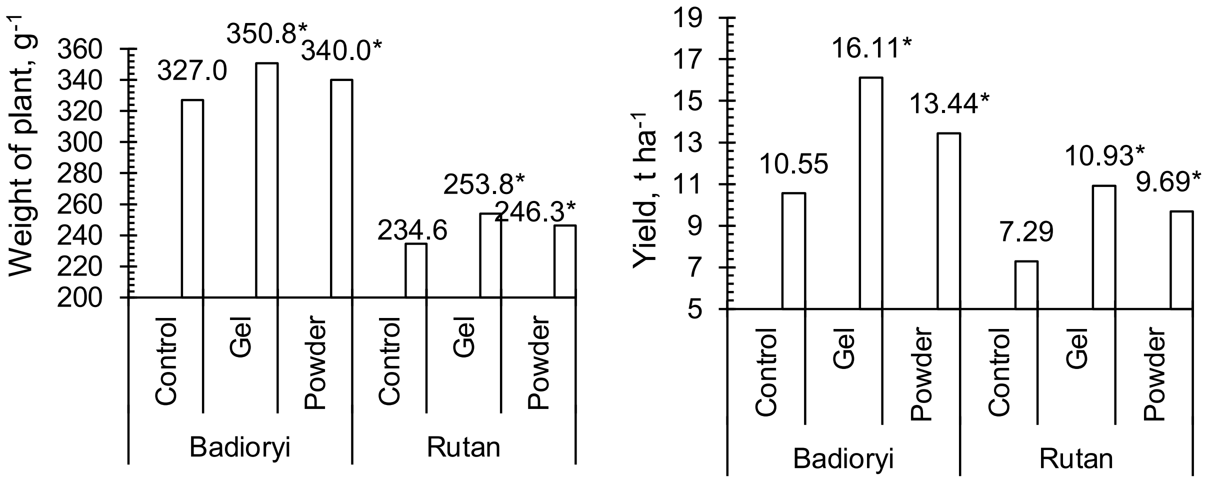

Figure 2. Weight of the plant (g^{-1}) and yield (t ha^{-1}) of the basil cultivars vs. various form of superabsorbent, (BBCH 55).

Results of statistical processing	Weight of the plant (g^{-1})			Yield (t ha^{-1})		
$LSD_{0.05}$ A	6.55	4.62	8.46	0.480	0.701	0.166
B	8.02	5.67	10.36	0.588	0.344	0.096
A×B	11.34	8.01	14.65	0.832	1.214	0.118

* show significance at the $P \leq 0.05$ probability levels.

The application of the absorbent in the form of a gel was more effective. Higher yields were observed by applying the absorbent in the form of a gel. Thus, the yield of the cultivars of Badioryi and Rutan was at the level of 16.11 and 10.93 t ha^{-1}, which exceeded the control by 5.56 and 3.64 t ha^{-1}, in accordance.

The use of superabsorbent polymer improves plant growth. For example, the total amount of raw cucumber biomass (*Cucumis sativus L.*) and fruit biomass increased by 840 and 494 g^{-1} per plant, in accordance Montesano et al. (2015). Another study with different varieties of potatoes (*Solanum tuberosum L.*) found an increase in tuber yield using superabsorbents locally in the furrows to a depth of 25 cm^{-1} Salavati et al. (2018). A similar result was found with the application of 60 and 90 kg ha, which increased the yield of potatoes by 38.2 and 50.5% relatively to the control when applying superabsorbents to a depth of 20 cm^{-1} Hou et al. (2017). Although the use of superabsorbents can improve plant growth, the depth of its use can significantly affect its effectiveness.

In the conditions of insufficient moisture, superabsorbents have a greater impact on plant productivity Fazeli Rostampour et al. (2013), Egrinya Eneji et al. (2013). The dry matter of sorghum (*Sorghum bicolor L.* Moench) increased only when there was a shortage of the water in the sandy loamy soil Fazeli Rostampour et al. (2013). In a 3-year study, the use of superabsorbents increased wheat yield relatively to the water-deficient years Grabinski et al. (2019). Similar results were obtained with beans (*Phaseolus vulgaris L.*) grown with superabsorbents Satriani et al. (2018).

CONCLUSION

The results of this study showed that increasing of the activity of antioxidant enzymes (catalase, superoxide dismutase and ascorbate peroxidase) in basil varieties indicates their resistance to the drought, and this is accompanied by an increase in chlorophyll content. Thus, the use of superabsorbent, which has the ability to absorb significant amounts of the water, improves growth processes and physiological responses of plants and can help plants in conditions of the water shortage.

That is, with the improvement of the water regime, the concentration of sugar, ascorbic acid, essential oil decreases.

The productivity of basil is increased with the use of superabsorbent polymers. Higher growth, yield, were observed with the introduction of the absorbent in the form of a gel compared to the control. This practice can be recommended to agricultural producers who deal with vegetables, in particular, basil in the areas of unstable or insufficient moisture.

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