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RESPONSE OF WINTER CANOLA (*Brassica napus* L.) TO TREATMENT WITH GROWTH REGULATORS AND BIOSTIMULATORS - A REVIEW

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Abstract

The main problem in the technology of growing winter oilseed rape comes down to overcoming adverse consequences in early and late development of winter oilseed rape, which leads to the failure of the harvest from the sown areas or unsatisfactory yields with low quality indicators. This necessitates the need to seek and use ways, methods and means to reduce or overcome these adverse consequences. One of the ways for this is the application of means /substances/ with growth-regulatory action and substances with biostimulating action. Therefore, it is necessary to study the influence of substances with growth-regulatory action and substances with biostimulating action. Rapeseed is a strategic crop for global agriculture. The application of growth regulators and biostimulators is an important element of the technology of growing winter oilseed rape. Plant growth regulators allow deployment of the productive potential of hybrids and increase the quality indicators of the production. They lead to morphological and physiological changes in plants, plant growth inhibition, inhibition of plant gibberellins biosynthesis and inhibition of sterol biosynthesis, reduction of internode elongation, increased chlorophyll content, delayed senescence, increased antioxidant potential and improvement in alkaloid production. Bioregulators reduce the biotic and abiotic stress in plants. Their use leads to an increase in cellular energy, the permeability of the cell membranes of the root system increases, the penetration of mineral nutrients from the soil solution into the plants is improved, which promotes better absorption of nutrients by the plant, the growth of the root system increases, the aboveground mass and dry matter yield. The application of plant bioregulators leads to an increase in productivity and its quality, but also contributes to the development of sustainable agriculture and the protection of the environment. Analytical review of cited sources and presented results regarding various aspects of impact on growth, development, productivity and quality gives reason to conclude that the toolkit that will be applied to develop strategies and biotechnological approaches to overcome stress in the development of rapeseed.

Key words*: rapeseed, growth regulators, biostimulators, yield, quality.*

INTRODUCTION

The rape (*Brassica napus* L.) is currently one of the most important oilseeds in Europe. In terms of cultivation technology and growing season, we distinguish between winter rape and spring rape (Bencze et al., 2020). Rapeseed is a strategic crop and for the global agriculture. Rapeseed (*Brassica napus* L.), also known as canola, is a plant with bright yellow flowers that is widely grown around the world, due to the variety of uses that its production finds. The culture has been known since 4000 BC.

Today, rapeseed oil production amounts to more than 13 million on an area of more than 260 million decares. The main producers of rapeseed worldwide are the EU (21%) and Canada (20%). They are followed by China (15%), India (14%) and Australia (5%) (Eskin et al., 2003; Filipova et al., 2017). Rapeseed is a valuable green fodder with high nutritional value, characterized by high fat and protein content (Ţîţei, 2021; Todorov, 2020; Todorov, 2021; Vasilev et al., 2021). In recent decades, rapeseed has been increasingly used to produce biofuels, as it can be blended with petroleum products (Filipova et al., 2017). According to Öztürk (2010), winter canola (*Brassica napus* L.) has the potential to become an alternative oil crop for edible oil production and for energy farming (biofuel production) for Turkey.

The cultivation of rape requires the application of a number of fungicides and herbicides, growth regulators and fertilizers. These chemicals threaten not only bees, but also many other species, including butterflies, birds and aquatic insects, and a chain reaction is possible throughout the food chain (Filipova et al., 2017).

In order to overcome some abiotic stress factors, such as drought, cold, water deficit, etc., plants need the application of products to stimulate their growth and development, to increase productivity and the quality of yields. These products affect the rate of physiological processes by being able to stimulate or slow down natural processes (Nickell, 1982; Kumar et al., 2013; Raza, 2021). Growth regulators and biostimulants do not constitute food for plants, but influence and control the course of life processes, the rate of growth and development.

The main problem in the technology of growing winter oilseed rape comes down to overcoming adverse consequences in the early and late development of winter oilseed rape, which leads to the failure of the sown areas or unsatisfactory yields with low quality indicators. That is why it is necessary to study the influence of substances with a growth-regulatory action and substances with a biostimulating action.

INFLUENCE OF GROWTH REGULATORS ON THE GROWTH AND DEVELOPMENT OF WINTER OILSEED RAPE (*Brassica napus* L.)

Matysiak et al. (2013) report that the use of plant growth regulators is an important element in plant breeding. In plants such as cereals and canola, plant growth regulators are used primarily to prevent plant lodging. Research, however, shows that plant growth regulators are not just anti-lodging agents, but also substances that, to a large extent, allow the full use of the plant's potential. It is estimated that, in plant growth, regulators account for only 3-4% of the plant protection products used worldwide. This group is still dominated by relatively old substances, such as: ethephon, chlorocholine chloride, and mepiquat chloride. There is also a smaller group of substances marketed relatively recently that are used as growth regulators including: trinexapac-ethyl or prohexadione-calcium. In recent years, triazole fungicides acting as growth regulators in the cultivation of oilseed rape, introduced on the market in the 1990s, have become an alternative to those previously used (Rajala et al., 2000; Rademacher, 2000; Rademacher et al., 2002). From the group of trizol fungicides, the growth regulators Follikur R and Karamba 60 SL have been used to regulate the growth and development of plants in recent years. With earlier sowing or a warmer and more humid autumn, the plants develop a rosette with more than 6-8 leaves/i.e. outgrow/. As a result, the root system develops poorly, plants are more easily frostbitten and attacked by diseases, found Yankov et al. (2012). In early spring, in a warm and wet winter, canola grows rapidly, the stalks become tall and thin, they lay down easily, and the crops are more susceptible to disease and pests.

The authors believe that this makes harvesting the plants difficult and reduces yields. Therefore, in autumn or spring, rapeseed can be treated with the growth regulator Folikur R, in a dose of 50-150 ml/day. For the same purpose, the growth regulator Karamba 60 SL can be used - brought in in the fall in a dose of 70 ml/day, in phase 4-6 canola leaf. In spring, this preparation is used from the 9th and more visible upright internodes until the appearance of the first petals of the flower, at a dose of 100 ml/day. In countries with warm and humid autumn, in order to prevent earlier germination and overgrowth of plants, seeds are treated with special synthetic polymers. Polymer-treated seeds are known as Extenders. They arrest the development of the plants until spring, improve the optimal density and contribute to an increase in yield. With the growth regulators, the growth of plants is controlled, the formation of biomass, the height is regulated - thus, the crop becomes more cold-resistant, the risk of laying is reduced.

Overwintering of oilseed rape depends on the stage of plant development at the end of the growing season before winter, but plant development also depends on the variety used, application of growth regulators and agro-climatic factors report Balodis et al. (2011). Before the winter period, the canola plant must establish sufficient vegetative mass and must reach certain parameters of the root collar, diameter, height of the growing point above soil level and number of leaves. The risk of overgrowth exists with very early sowings and warm autumns.

Growth regulation is one option for controlling overgrowth in autumn. Cell division and cell elongation of branches can be controlled by the application of growth regulators, resulting in a change in yield structure and reduced plant height, as well as reduced leaf area and an increased root/branch ratio (Bruns et al., 1990; Fisahn et al., 1995). Some researchers from Lithuania (Gaveliene et al., 2002; Miliuviene et al., 2004) believe that the application of a growth regulator increases the number of leaves of the plant and the diameter of the root collar and decreases the height of the growing point of winter rape, as this way favors the winter hardiness of the culture.

Some effects of fungicides are used to regulate plant growth and, when applied, reduce plant height, improve stability to prevent lodging, affect yield structure, and effectiveness is cultivar dependent (Rao et al., 1991; Gans et al., 2000). Other fungicides of the strobilurin group also contribute to high yields by altering the cellular mechanisms of plant growth (Venancio et al., 2003). According to the authors, since the introduction of different types of active fungicides, the concept of disease control has acquired new perspectives because of the positive physiological effects of these chemicals on plants.

When treated with triazole and strobilurin together with plant growth regulators, according to Ruske et al. (2003) and Zhang et al. (2010) observed a variety of morphological and physiological changes in different plants, including plant growth inhibition, reduction of internode elongation, increased chlorophyll content, increased chloroplasts, thicker leaf tissue, increased root-to-branch ratio, delayed senescence, increased antioxidant potential and enhancement of alkaloid production. Gaveliene et al. (1998) studied the action of Fungicide Juventus 90 (as a growth regulator) in crops, with different sowing dates, and the treatment was carried out at the 4-6 true leaf phase. Early sowing dates for winter oilseed rape create conditions for overgrowth, which is considered a risk for overwintering plants, the author team found.

Oilseed rape is highly susceptible to the appearance of diseases such as light leaf spot, white mold and white mold. These diseases can cause a decrease in seed yield up to 1 t/ha. Triazole fungicides are commonly used to protect canola against these fungal diseases. Some of these fungicides have additional plant growth regulatory properties (Luster et al., 1993; Coules et al., 2002).

From a biochemical point of view, the properties of some triazoles are due to their double effect on plants: inhibition of the biosynthesis of gibberellins in the plant (retarding properties) and inhibition of sterol biosynthesis (fungicidal properties). Substances with such dual action are also metconazole and tebuconazole, researchers note, while flusilazole only shows fungicidal activity (Dapprich et al., 2002; Rademacher, 2000; Berry et al., 2009). The properties of metconazole and tebuconazole go far beyond retardation, the authors believe. Studies of these substances can be used to model oilseed rape crops and this action is closely related to plant density.

According to Pits et al. (2008), the possibility of high yields in winter oilseed rape is achieved through the use of agrochemicals, the application of which is important in the fight against pests and diseases. Reduction of harvest losses also depends on application of growth and ripening regulators. The results of their research specify that delaying canola harvest has a significant impact on seed yield. Losses from this delay can be reported up to 10.9 q ha^{-1} when the Caramba preparation is applied, especially in combination with the application of the Reglone preparation.

A method for assessing the mechanical resistance of the rape stem, which not only allows determining the resistance of the corresponding seed varieties to laying in the field that can be used in seed production, but also allows determining the possible effects of the application of certain regulators of growth, apply Tys et al. (2007a; 2007b). The authors report that the effect of the growth regulator Caramba on the mechanical properties of the canola stem was positive only when applied in the fall and spring. According to them, climatic conditions have a significant influence on the mechanical resistance of the canola stalk.

In winter oilseed rape, triazole application reduces the rate of photosynthesis by reducing stomatal conductance (Zhou, 1996). Berova et al. (2014) studied the influence of Folikur 250 EB (from the triazole group) and Karamba Turbo (from the imidazole group) preparations on the growth and photosynthetic activity of rape plants. The preparations Karamba Turbo and Folikur 250 EU in a dose of 100 ml da^{-1}

suppress the growth of above-ground organs and accelerate the formation of the roots of the Clearfield hybrid PX100 rapeseed plants. The photosynthetic activity of the leaves, determined by the amount of photosynthetic pigments and parameters of leaf gas exchange, is higher in plants treated with Folikur 250 EB and Karamba Turbo.

INFLUENCE OF GROWTH REGULATORS ON THE PRODUCTIVITY AND QUALITY OF WINTER OILSEED RAPE (*Brassica napus* L.)

Kumar et al. (2013) reported that different techniques such as osmo-priming, seed treatment and application of chemicals used to induce plant growth are used to achieve maximum seed yield. Some fungicides of the strobilurin group also serve to increase yields by altering cellular plant growth mechanisms (Venancio et al., 2003). According to the same authors, after the introduction of various types of active fungicides, the concept of disease control gained new perspectives because of the positive physiological effects of these chemicals on plants.

Evaluation of the influence of growth regulators (metconazole, di-1-P-menthene, dimetipine) and desiccants (diquat, glyphosate) on yield and quality of a mass of 1000 seeds was made by Pits et al. (2008). Results show that delaying harvest by 10 days significantly affects seed yield, with losses from this delay being of the order of 10.9 q ha^{-1}. The applied ripening regulators (Reglone and Roundup) the authors found to have a negative effect on yield growth, causing it to decrease by about 2-3 q ha^{-1}. Only for the reglon applied during the second harvesting period, a weak influence on yield parameters was recorded.

When treated with triazole and strobilurin together with plant growth regulators, according to Ruske et al. (2003) and Zhang et al. (2010) observed a variety of morphological and physiological changes in different plants, including plant growth inhibition, reduction of internode elongation, increased chlorophyll content, increased chloroplasts, thicker leaf tissue, increased root-to-branch ratio, delayed senescence, increased antioxidant potential and improvement in alkaloid production. In winter oilseed rape, triazole application reduces the rate of photosynthesis by reducing stomatal conductance (Zhou, 1996).

The fungicidal group of strobilurins cause a decrease in ethylene concentrations, which leads to degradation of cytokinins and results in delayed senescence in winter oilseed rape (Ijaz et al., 2012).

According to the same authors, the application of strobilurin fungicides keeps the photosynthetic green leaf area active for a longer period, which increases the amount of assimilates required for grain filling, which can lead to higher yield. These fungicides have also been reported to control lodging and improve seed yield in cereals in earlier studies, but according to Ijaz et al. (2015) little information is available on the use of these fungicides in combination with plant growth regulators in oilseed crops. In a study of winter oilseed rape using triazole and strobilurin fungicides, Ijaz et al. (2015), concluded that positive effects on plant growth were observed. According to the authors, application of growth-regulating fungicides can effectively control over-sized pods to reduce lodging and achieve optimal seed size.

Positive yield effects were achieved after combined application of triazole in BBCH 53 and strobilurin fungicides in BBCH 65, compared to their single applications. Quality parameters of rapeseed oil, including oil content, fatty acid profile, free fatty acids and peroxide number, can be affected by fungicide application, but are also dependent on weather conditions and the influence of the variety.

Changes in environmental conditions have resulted in different types of stress that affect plant growth, development and survival. To what extent growth regulators improve the tolerance of plants to unfavorable environmental conditions was investigated by Ahmadi et al. (2016). The effect of drought stress on oilseed rape was studied at three levels of irrigation and 10 levels of foliar application of growth regulators (100, 200, 300 $mg.l^{-1}$ ascorbic acid, 100, 200, 300 μmol; salicylic acid; 10, 20 , 30 vol% methanol and distilled water as a control treatment). The author's team found that the application of growth regulators increased seed yield due to an increase in the accumulation of proline and phytosynthetic pigments and their effect on components of seed yield. Foliar application of growth regulators, such as ascorbic acid, salicylic acid and methanol, improved seed yield and oil quality of canola under optimal water supply and drought stress regimes, Ahmadi et al. (2023) in their research. Water deficit during the flowering and ripening phases leads to a decrease in rapeseed yield by 38% and 15%, respectively, compared to the optimal irrigation regime.

Studies on the different effects of the application of growth regulators in winter oilseed rape species are of extreme importance for the development of the yield potential of hybrids and the improvement of the quality indicators of the production produced by them. For farmers, this information is useful for the correct use and maximum effectiveness of the application of growth regulators in this valuable oilseed crop. For researchers, it is important to identify the phases of plant development in which the use of growth regulators is most effective. To compare the effects of different treatments as they vary according to growing conditions, time of sowing, stages of plant development and the cultivar used.

EFFECT OF BIOSTIMULANTS ON THE GROWTH AND DEVELOPMENT OF WINTER OILSEED RAPE (*Brassica napus* L.)

Plant bioregulators influence biological responses in plant tissues and affect their biochemical, physiological, and genetic processes (Gastol et al., 2013). According to Olaiya et al. (2013) their use provides a new approach to manipulate plant biochemistry to increase productivity and quality. Biostimulants are usually complex mixtures containing organic (e.g. seaweed extracts, vermicompost leachate, protein hydrolysates, humic substances, smoke water), microbial (fungi and bacteria) and/or inorganic components (Si, Se) (Brown et al., 2015; Colla et al., 2015; Du Jardin, 2015; Gupta et al., 2021; Shahrajabian et al., 2023). They improve plant growth and health by stimulating natural processes in a minimal amount instead of directly controlling plant growth (Rouphael et al., 2018). In 2012, over 6.2 million ha were treated with biostimulant products in Europe, making Europe the largest market globally (Calvo et al., 2014; Watkins, 2015).

The report cited EU sales of over £450 million and indicated that the market was growing rapidly (Agrow Biostimulants, 2015). There are many biostimulants on the market that manufacturers claim can facilitate nutrient uptake, increase plant tolerance and recovery from abiotic stress, improve plant metabolic efficiency, improve yield quality, improve the efficiency of other agricultural inputs (nutrients and plant protection products), improving the physicochemical properties of the soil, improving the efficiency of water use, increasing yield, and favoring the activity of soil microorganisms. The term "biostimulant" covers anything that can be added to a plant or soil to improve plant growth beyond basic fertilization, except for those products that have a definite "pesticidal" effect. It is very difficult for growers and agronomists to know which products work and which do not, or in which situations products work best, as there is very limited independent information available (Storer et al., 2016).

According to Sikorska et al. (2022) biostimulators, immune stimulants or bacterial vaccines are becoming standard elements in the production technology of many types of fields, fruit and vegetable crops. The authors established the influence of biostimulators containing microorganisms and micro- and macroelements, phosphorus and potassium and silicon on the morphological features of the rosette and the increase of the fresh and dry mass of the above-ground part of the rosette and the root system of three winter rape varieties. Application of the biological preparation U g max significantly increased the number of rosette leaves (on average by 13.9%), the length of the main root (on average by 2.3 cm), the diameter of the root neck (on average by 4.2%), fresh and dry weight of the above-ground part of the rosette (on average by 6.0% and 6.6%) and fresh weight of the root system (on average by 0.88 g) compared to the control variant.

The application of biostimulants affects the development of plants in different aspects. According to Malarz et al. (2008) and Sikorska et al. (2018) after treatment, a positive influence on plant height was reported. It has been reported to increase the number of pods per plant (Przybysz et al. 2008). Research has shown an increase in the number of seeds per pod (Harasimowicz-Hermann, 2008; Malarz et al., 2008). Other parameters that affect the productivity of canola are the mass of 1000 seeds and seed yield. Gugała et al. (2019) reported a positive trend after the use of biostimulators in rape.

The use of herbicides often has a negative effect on the growth of oilseed rape. Experimental results indicate that the microbial biostimulant “NaturGel” used before the herbicide reduces the negative effects of the herbicide, besides, it increases the growth and development processes of the tested plants, serving as an activator of the non-enzymatic defense system (Jankauskienė et al., 2024). According to the authors, the partial replacement of herbicides with the microbial biostimulant "NaturGel" strengthens the vitality of crops, increases competitiveness with weeds, improves the quality of yield and the sustainability of agricultural land use.

This approach can be applied to reduce the use of herbicides in agroecosystems and make a stepwise transition to organic farming, while also serving as information on the side effects of commonly used herbicides at recommended doses.

Wood vinegar has a combined effect of promoting crop growth, similar to plant growth regulators and is environmentally friendly, Zhu et al. (2021). Wood vinegar is formed from the condensation of smoke produced during biochar production. It contains mainly acetic acid, butyric acid, catechol and phenol. The authors reported the improvement of canola resistance to low temperature of 2-6°C by increasing superoxide dismutase activity and proline and soluble protein contents compared to the control. A significant reduction in the incidence of *Sclerotinia sclerotiorum* and *Peronospora parasitica* in rapeseed was also reported. Therefore, the researchers believe that the application of wood vinegar, due to its combined effects on crop growth and yield, is of great importance for sustainable agriculture, crop ecology, and environmental protection.

INFLUENCE OF THE BIOSTIMULATORS ON THE PRODUCTIVITY AND QUALITY OF WINTER OILSEED RAPE (*Brassica napus* L.)

With the use of "Vermyodis" (growth regulator), a certain amount of nutrients, such as nitrogen, phosphorus, potassium, calcium, magnesium, boron and other microelements, as well as amino acids, vitamins and growth substances, enter the plants. These substances activate the enzymatic activity of all plant cells and the formation of stimulating compounds by the plant itself. As a result of its use, cellular energy increases, the physicochemical properties of the protoplasm change, and metabolism intensifies. In addition, the permeability of the cell membranes of the root system is increased, the penetration of mineral nutrient elements from the soil solution into the plants is improved, which promotes better uptake of nutrients by the plant (Bachmat et al., 2019). The flow of sugars, amino acids, vitamins and hormones into the plant is improved. The authors found that water flow and oxygen uptake by the plants were accelerated, which in turn enhanced plant respiration, cell division, photosynthesis, and protein synthesis. The growth of the root system increases, the above-ground mass increases, the yield of dry matter increases, therefore the plant's vital activity improves.

Stoyanova et al. (2018) studied the influence of complex preparations based on biologically active substances of natural organic origin in spring rapeseed and vegetation herbicide, applied in an optimal and double-increased dose in the conditions of the IZS Obraztsov chiflik Ruse. The applied foliar treatment with the developed biologically active preparations in the rosette and beginning of flowering phases contribute to a slight increase in the yield of spring rapeseed, compared to the control variant. The introduction of the biologically active preparations, applied after the introduction of the vegetation herbicide Targa Super 5EK in optimal and increased doses in the rosette and beginning of flowering phases, have a positive effect on the resistance to ecological stress. An increase in the content of total nitrogen in the seeds was measured from the variant with the application of the biologically active preparations PGA and PGA-h, and the richest in crude protein were the spring rape seeds from the variant with the application of PGA and targa Super 5EK in an increased dose (400 ml da^{-1}).

To increase the crude fiber content of winter rape from 0.15 to 0.84 g/kg s.m. also reported by Gugała et al. (2019). The increase was registered after application of plant biostimulators. Natural plant biostimulants lead to an increase in seed protein content by an average of 8.8 g/kg d.m. reported by Yankowski et al. (2016b). A number of researchers have reported an increase in the crude fat content of winter rapeseed after treatment with natural plant preparations (Spychaj-Fabisiak et al., 2011; Kováčik et al., 2016; Gugala et al., 2019).

In their research, Gavelienė et al. (2018), investigated the effects of biostimulants on frost tolerance under laboratory-controlled cold conditions and on growth, development, overwintering and productivity of winter canola and winter wheat in natural field trials. The effect of free amino acids, macroelements and microelements contained in the biostimulants Ruter AA, Terra Sorb and Razormin was investigated on rapeseed varieties "Hornet H" and winter wheat "Skagen" and "Kovas" using morphometric methods. They found that biostimulants applied to canola at the BBCH 13-14 stage and to wheat at the BBCH 14-15 stage under controlled conditions of low temperature stress increased the frost resistance of seedlings.

Biostimulators more actively increase the frost resistance of rapeseed seedlings at –5°C compared to that of wheat seedlings. A temperature of –7°C was lethal for rapeseed seedlings, while the resistance of wheat seedlings was increased under the influence of the tested biostimulants compared to that of control seedlings. In natural field experiments, these biostimulators have had a significant effect on plant growth in the fall, their adaptation to the cold, wintering of plants, resumption of vegetation, and this supports the formation of productive elements. The effects of Razormin (200 mL/ha), Terra Sorb (2 L/ha) and Ruter AA (1 L/ha) were significantly higher on the growth parameters of winter wheat compared to the productivity of winter canola.

In a study of the influence of the biostimulator Tytanit®, the biostimulator Asahi®SL and the biostimulator Silvit® and the control without biostimulators in three winter rapeseed hybrids Gugała et al. (2019) determined the concentration parameters of protein, crude fat and crude fiber in the seeds of three winter canola morphotypes. Investigating the effect of biostimulators on the quality and quantity of the yield, the authors prove that biostimulators reduce the total protein content (on average from 0.8 to 1.75 $g \cdot kg^{-1}$ of d.m.) and increase the concentration of crude fat (on average from 0.71 to 1.93 $g \cdot kg^{-1}$ of d.m.) and crude fiber (average of 0.15 to 0.84 $g \cdot kg^{-1}$ of d.m.) compared to the control.

It was found that the growth regulator "Vermyodis" significantly affects seed germination, leaf size and photosynthetic activity of rape agrocenoses of the winter hybrid, resulting in an increase in crop productivity (Bachmat et al., 2019). By treating the seeds with the growth regulator in a dose of 5 l/t and spraying the plants during the growing season with the same preparation twice at 4 l/ha at a seeding rate of 0.6 million/ha seeds, the highest field germination was achieved (88.7%) and plant survival (97.7%). In the same variant in the flowering phase, the leaf area is 44.7 thousand m2/ha, which is 8.1 thousand m2/ha more than the control. The highest accumulation of solids is observed in the waxy maturity phase. The crop's photosynthetic potential of 0.375 million m^2/d/ha was relatively increased by 1.27 g/m^2 per day over the control. The yields reached 4.09 t/ha, or 0.6 t/ha more than the control (Bachmat et al., 2019).

Petrova et al. (2017) present results of treatment with new phytostimulant preparations on biometric parameters, seed yield and production quality of two spring oilseed rape varieties. It was found that the two most effective formulas applied in the tested concentrations and doses by stimulating the growth and development of spring oilseed rape cultivars contributed to an increase in seed yield on average by 20/23% (cv Pacha) and 28/17% (cv Jura), as well as the biological yield of protein and fat. Sikorska et al. (2022) found that foliar feeding with a biostimulator containing amino acids did not significantly affect the increase in the number of productive branches, pods per plant and pod length. When combining foliar fertilizers (rich in S and B) and biostimulants, the authors reported an increase in the components of seed yield.

CONCLUSIONS

The application of growth regulators and biostimulators is an important element of the technology of growing winter oilseed rape.

Plant growth regulators allow deployment of the productive potential of hybrids and increase the quality indicators of the production. They lead to morphological and physiological changes in plants, plant growth inhibition, inhibition of plant gibberellins biosynthesis and inhibition of sterol biosynthesis, reduction of internode elongation, increased chlorophyll content, delayed senescence, increased antioxidant potential and improvement in alkaloid production.

Bioregulators reduce the biotic and abiotic stress in plants. Their use leads to an increase in cellular energy, the permeability of the cell membranes of the root system increases, the penetration of mineral nutrients from the soil solution into the plants is improved, which promotes better absorption of nutrients by the plant, the growth of the root system increases, the aboveground mass and dry matter yield. The application of plant bioregulators leads to an increase in productivity and quality, but also contributes to the development of sustainable agriculture and the protection of the environment.

Analytical review of cited sources and presented results regarding various aspects of impact on growth, development, productivity and quality gives reason to conclude that the toolkit that will be applied to develop strategies and biotechnological approaches to overcome stress in the development of rapeseed.

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