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THE EFFECT OF PLANT STIMULANT/FERTILIZER "RESISTIM" ON GROWTH AND DEVELOPMENT OF STRAWBERRY PLANTS

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A B S T R A C T

In intensive fruit production, in order to obtain high yields, it is necessary to use high fertilization rates as well as plant protection products. An alternative to that kind of production is presented by natural stimulators of plant growth and development called biofertilizers, biopreparations, biostimulators or phytostimulators. They are preparations of natural (plant or animal) origin, harmless to humans and the environment. Biostimulators contain biologically active substances, i.e. plant hormones, enzymes, macro- and microelements, and other compounds that stimulate the growth and development of plants.

New approaches to agriculture tend to use environmentally friendly and safe products with a broad spectrum of activity. Nowadays many preparations offered for crop production are designed not only to fertilize the plants and stimulate their growth, but also to protect them from diseases or pests. Phosphite-containing products act as fertilizers or fungicides, and sometimes as biostimulants. "Resistim" is an activating stimulant and fertilizer composed of a potassium phosphite and natural betaines.

The aim of the study was to evaluate the influence of "Resistim" on the growth and development of three strawberry cultivars (*Fragaria x ananassa* Duch.). Two of them are short-day cultivars: 'Honeoye' and 'Elsanta', while 'Selva' is a day-neutral cultivar. The experiment was established in October 2008 under controlled conditions in a glasshouse and was carried out for three months. The plants were planted into a mixture of sandy mineral soil and peat in rhizoboxes enabling visualization of root growth and development. The plants were fertilized with standard NPK fertilization (N – 1.02 g, P – 1.9 g, K – 0.78 g per rhizobox), "Resistim" at the dose of 0.2% and 0.4% and NPK (N – 1.02 g, P – 1.9 g, K – 0.78 g) with "Resistim" at the dose of 0.2% and 0.4%, and

watered by an automatic, computer-controlled watering system. Control plants were not fertilized. The data obtained showed significant differences in the responses of the cultivars to "Resistim" treatment. 'Honeoye' was the most responsive, although the other two cultivars also responded positively to the treatment with "Resistim". Further field research is required to determine whether the supplemental application of "Resistim" can be beneficial for strawberry fruit production.

Key words: biostimulator, Phi-based fertilizer, plant growth, strawberry cultivars

INTRODUCTION

Recently, strawberry growers have been mostly interested in growing cultivars for the fresh market. That kind of production is more profitable, but on the other hand it requires more complicated technologies and well-educated workers. High quality of the fruit for the fresh market is an important factor attracting customers and determines their choice and prices. The cost of fruit production for the fresh market needs to be calculated and trials of more efficient methods and technologies should be taken into consideration. New environmentally friendly mineral-organic fertilizers can improve fruit quality and yield of dessert strawberry cultivars. The desired effects are obtained through the activity of fertilizer's components, which very often belong to different groups of natural hormones, elicitors, vitamins, flavonoids, amino acids, etc.

"Resistim" is an activating liquid fertilizer consisting of soluble phosphorus (6.7% in phosphite form), soluble potassium (10.9%) and natural betaines (Mandops Ltd.). This fertilizer can be used for a wide range of crops, including vegetable and fruit crops. According to the label "Resistim" is easily absorbed by the plants and transported upwards and downwards within the plant's organs. "Resistim" fertilizer can be applied as a foliar spray or through fertigation. According to the producer's recommendations, the ingredients of "Resistim" can increase plant vigour, provide nutrients, and also protect the plants against some diseases.

Phosphorus (P) is one of the components of "Resistim" and belongs to the group of macro elements, which play an important role in plant growth and development. Phosphorus has a direct influence on the yield and its quality. Positive interaction is also known to occur between phosphorus and the other nutrients such as nitrogen, sulphur and zinc (Kang and Juo, 1979). Phosphorus in fertilizers is usually in the form of various salts of phosphoric acid (H_3PO_4). In weakly acidic solutions they dissociate into dihydrogen phosphate ($H_2PO_4^-$) ions whereas in neutral and weakly alkaline solutions they dissociate into hydrogen phosphates (HPO_4^{2-}). Both of these forms are absorbed by plants, with dihydrogen phosphate being more readily uptaken (Street and Kidder, 1989).

Phosphorous acid (H_3PO_3) is the other form of phosphorus, which can be applied in agriculture. During dissociation, phosphonate ions (HPO_3^{2-}), also called phosphite, are released. The phosphite form of phosphorus is more soluble than phosphate and its uptake by the leaves and roots is more efficient. Thus, at high concentrations phosphite can be toxic to plants. Once uptaken by the plant, it plays various roles, as a macronutrient, plant strengthener or plant protectant. It is the level of oxygen that determines the role that can be played by each form of phosphorus (Lovatt and Mikkelsen, 2006).

Phosphate ions are the primary plant nutrient (Ouimette and Coffey, 1989). So far, no plant enzyme has been described to be able to oxidize phosphite into phosphate. Thus the phosphite form is very stable in plants (Smillie et al., 1989).

Phosphite has both direct and indirect influence on plant growth and is regarded as a very valuable product for agricultural applications. It inhibits the process of oxidative phosphorylation in the metabolism of the oomycete group of fungi (McGrath, 2004). Phosphite is known to control *Phytophthora* root and crown rot in tomato and pepper plants (Förster et al., 1998), and was shown to be effective for controlling strawberry leather rot caused by *Phytophthora cactorum* (Rebollar-Alviter et al., 2005). Wild et al. (1998) reported that phosphite applied to wound-inoculated apples of the cultivars 'Granny Smith' and 'Golden Delicious' was effective in reducing incidence of diseases caused by *Penicillium expansum*, *Botrytis cinerea* and *Mucor piriformis*. Phosphite preparations have been proven to be effective against *Pythium* and *Phytophthora* (Brunings et al., 2005).

Phosphorus in phosphite form is found to act as an elicitor that helps plants to protect themselves by stimulating the shikimic acid pathway. During this process plants produce and collect phytoalexins that enable them to protect the plant tissue against pathogen attack (Thao and Yamakawa, 2009).

There are a number of products on the market that include phosphite as an active ingredient. Some of them are sold as fertilizers and some as fungicides. A very popular fungicide, which relies on phosphite ion activity, is Aliette made by Bayer CropScience (Fosetyl-Al – releases phosphite as a breakdown product), (Guest and Grant, 1991). That product is reported to be very effective against leather rot and other *Phytophthora* diseases in strawberry plants and other crops as well. Due to highly systemic properties of this product, its components are easily transported downwards and upwards, controlling foliar and root diseases. Aliette is also reported to be an effective fungicide against such species of fungi as *Colletotrichum* and *Phomosis*, which makes that product effective across a broader spectrum than that given on its label (www.nasga.org/research/Comparison_of_Phosphorous_Acid_Products1.doc).

Potassium is another macronutrient present in "Resistim". It is responsible for the correct osmotic gradient that enables water, and thus nutrients, to effectively enter the root system. When the potassium content is within the optimal range, structural stability of the plant is ensured. Potassium also plays an essential role in the processes of photosynthesis and transport of the products to storage organs in the plant. Consequently, the dry matter content of the crop is directly affected by the potassium. Furthermore, potassium is involved in many enzymatic reactions within plants and for all these functions it is irreplaceable (Lityński and Jurkowska, 1982; Krzywy, 2000).

Betaines are the other components of "Resistim". There is evidence proving the essential role of betaines in overcoming stress conditions. Frost, water stress, soil salinity, soil acidity, nutrient deficiencies/toxicities are common stresses faced by plants. Under such conditions betaines are accumulated in plant tissues and help them to maintain or improve growth and development. Application of exogenous betaines improved growth, yield and quality of the plants grown under unfavorable soil conditions (Ashraf and Foolad, 2007).

The aim of this study was to evaluate the influence of "Resistim" on the vegetative growth and development of three strawberry cultivars grown under controlled glasshouse conditions.

MATERIAL AND METHODS

In the autumn of 2008, 'frigo' plants of three strawberry cultivars: 'Honeoye', 'Elsanta' and 'Selva' were planted in rhizoboxes. Each rhizobox was filled with 1.8 kg of sandy mineral soil and peat (mixed in the ratio of 1:1, v/v). The front wall of the rhizobox is transparent, which enables visualization of root growth and development (Sas Paszt and Żurawicz, 2005; 2004; Sas et al., 2003). The remaining walls of the rhizobox are made of PCV. To encourage root growth in the direction of the transparent wall, the rhizoboxes were placed at an angle of 60° to the horizon. The transparent wall of each rhizobox was covered with a black plastic sheet to avoid photo inhibition and ensure root growth in the direction of the transparent wall, according to geotropism.

The following four fertilization combinations were applied to the plants:

- Control – not fertilized.
- "Resistim" – treated with "Resistim" (Mandops Ltd.) at the dose of 0.2% and 0.4%.
- NPK – standard NPK fertilization (N – 1.02 g, P – 1.9 g, K – 0.78 g per rhizobox).
- "Resistim" + NPK – NPK fertilization (N – 1.02 g, P – 1.9 g, K – 0.78 g) with an extra "Resistim" application at the dose of 0.2% and 0.4%.

The NPK standard fertilization was added to the soil prior to filling in rhizoboxes in the form of urea (2.22 g per rhizobox), potassium sulphate (4.22 g per rhizobox) and triple superphosphate (9.39 g per rhizobox). Microelements were not added to the plants because soil analysis showed that their level was optimal for plant growth and development. "Resistim" was applied four times as foliar spray. The first foliar treatment, at the concentration of 0.2%, was carried out when the first three leaves were emerging. Subsequent applications, at the concentration of 0.4%, were made at 10-day intervals. For each of the applications, adjuvant Superam 10 AL (Danmar) was added to the working solution according to producer’s recommendations (5 ml of adjuvant to 10 l of water).

Each experimental combination was represented by 8 plants grown in 4 rhizoboxes (2 plants per rhizobox). The experiment was located in a glasshouse at a temperature of 19/15 °C (±2 °C) day/night. The natural day light was supplemented with artificial illumination to keep 16 h photoperiod. Water was applied according to the plant needs and soil moisture content.

After 3 months the plants were removed from the rhizoboxes. The plants were divided into shoots and roots. Fresh and dry matter of the roots and shoots were assessed separately for each plant organ according to the analytical procedure developed by Ostrowska et al. (1991). Measurements of the total shoot and root area, total root and shoot volume, total root length, total root volume, root diameter and the number of root tips were done with an image analysis system operated by Hewlett Packard’s 74000c root scanner, controlled by Delta-T Scan software. The intensity of the green colour of the leaves was measured with the use of a SPAD tool, used for determination of intensity of green colour of the leaves (highly correlated with chlorophyll content in the leaves).

The data were elaborated statistically by ANOVA and significance of the differences between the treatments were evaluated by Student-Newman-Keuls multiple range tests at $p = 0.05$.

RESULTS

Strawberry plants cv. ‘Honeoye’

Following the treatments with “Resistim”, the plants of the cultivar ‘Honeoye’ showed significant increase in fresh matter of the shoots, compared to the other treatments (Tab. 1). Dry matter of the shoots was also positively affected by “Resistim” application, but statistical differences were present only between plants treated with “Resistim” and Control treatment. Similarly application of the fertilizer positively influenced the number of plant leaves. Their number was significantly increased by the treatments with “Resistim” in comparison to the NPK treated plants. The shoot area and shoot volume of the plants treated with “Resistim” and “Resistim” combined with NPK fertilization were significantly increased in comparison to the Control plants. The SPAD index (highly correlated with the chlorophyll content in the leaves) did not differ significantly between the plants from all the treatments.

Strawberry plants ‘Honeoye’ treated with the phosphite-derived fertilizer significantly increased fresh and dry root biomass compared only with the plants from Control application (Tab. 1). In comparison

Table 1. Shoot and root growth parameters of strawberry plants cv. 'Honeoye' treated with "Resistim", NPK and "Resistim" + NPK, in comparison with not-fertilized plants (Control)

	Growth parameters	Treatments			
		Control	"Resistim"	NPK	"Resistim" + NPK
Shoots	Fresh matter of shoots [g]	3.4 a*	5.0625 b	3.75 a	4.0625 a
	Dry matter of shoots [g]	0.8 a	1.3125 b	1.0125 ab	1.0875 ab
	Number of leaves	5.25 a	7.125 b	5.875 a	6.125 ab
	Shoot area [cm^2]	86.4175 a	127.476 b	95.145 ab	124.409 b
	Shoot volume [cm^3]	74.7662 a	115.034 b	94.7963 ab	113.055 b
	Green colour of the leaves SPAD	729.5 a	745.25 a	797.25 a	786.25 a
Roots	Fresh matter of roots [g]	6.3875 a	10.8625 b	8.925 b	8.725 b
	Dry matter of roots [g]	1.6375 a	2.9 b	2.275 ab	2.2625 ab
	Root volume [cm^3]	23.6575 a	51.2475 b	30.9237 a	55.41 b
	Root diameter [mm]	0.49125 a	0.53375 a	0.5075 a	0.6675 b
	Root area [cm^2]	47.2025 a	78.7388 b	52.3537 a	57.22 a
	Number of root tips	860.875 a	1037.88 a	1098.13 a	1143.63 a
	Roots length [m]	10.6688 a	10.4163 a	12.1062 a	10.6125 a

*Numbers followed by different letters are significantly different at p = 0.05 according to Student-Newman-Keuls test

to NPK, application of "Resistim" only or "Resistim" with NPK increased significantly the volume of strawberry roots. "Resistim" applied as foliar spray to the plants fertilized with standard NPK resulted in a significantly higher root diameter of the plants, whereas "Resistim" on its own significantly increased root area. The number of root tips of the plants from all the experimental combinations did not differ significantly nor was the root length significantly affected.

Strawberry plants cv. 'Elsanta'

The 'Elsanta' strawberry plants showed less pronounced differences in shoot and root growth parameters revealed a cultivar-dependent response to the applied treatments. The number of leaves, shoot fresh and dry matter, shoot area and volume, and the green colour of the leaves of 'Elsanta' plants did not differ significantly (Tab. 2).

Application of the "Resistim" fertilizer to the plants of 'Elsanta' cultivar significantly increased root volume, root area, number of root tips and root length in comparison with the plants treated with standard NPK fertilization. Plants from the combination where only NPK was applied had significantly lower number of root tips and root length in comparison with the plants fertilized with NPK and sprayed with "Resistim".

Table 2. Shoot and root growth parameters of strawberry plants cv. ‘Elsanta’ treated with “Resistim”, NPK and “Resistim” + NPK, in comparison with not-fertilized plants (Control)

	Growth parameters	Treatments			
		Control	“Resistim”	NPK	“Resistim” + NPK
Shoots	Fresh matter of shoots [g]	4.5375 a*	4.15 a	4.1375 a	4.0875 a
	Dry matter of shoots [g]	1.1825 a	1.1625 a	1.0625 a	1.0625 a
	Number of leaves	6.25 a	6.5 a	6.625 a	6.75 a
	Shoot area [cm^2]	119.22 a	122.566 a	116.726 a	128.819 a
	Shoot volume [cm^3]	114.19 a	88.4587 a	106.046 a	113.061 a
	Green colour of the leaves SPAD	706 a	671.25 a	734.5 a	746 a
Roots	Fresh matter of roots [g]	9.625 a	8.8875 a	7.7375 a	7.275 a
	Dry matter of roots [g]	2.75 b	2.5375 b	2.2 ab	1.65 a
	Root volume [cm^3]	42.3838 b	37.6625 b	25.1175 a	24.7288 a
	Root diameter [mm]	0.5975 ab	0.52 a	0.70625 b	0.66875 ab
	Root area [cm^2]	69.2525 ab	73.915 b	44.1963 a	55.7188 ab
	Number of root tips	1061.38 b	1269.25 b	563.625 a	954.125 b
	Root length [m]	13.0663 b	13.575 b	5.4475 a	11.4413 b

*Explanations: see Table 1

Strawberry plants cv. ‘Selva’

The shoot growth of ‘Selva’ strawberry plants was not affected by “Resistim” applications. Fresh and dry matter of the shoots, number of leaves, shoot area, shoot volume and the green colour of the leaves (the SPAD index) were not significantly different between treatments (Tab. 3).

For the root system, application of the “Resistim” fertilizer to the plants of ‘Selva’ cultivar significantly increased: number of root tips, root area and volume, as well as root length in comparison with standard NPK fertilization. Significant increase in the root area and root length were noticed for the plants treated with NPK and “Resistim” in comparison with those from NPK standard application.

DISCUSSION

Literature data indicate a beneficial effect of “Resistim” on plant growth and development. For example, Kołodziej (2009) reported a considerable improvement in the morphological traits and yielding of thyme plants sprayed with “Resistim”. Other authors reported beneficial effect of soil applications of “Resistim” at a concentration of 0.1% on the growth and development of pepper plants, in which shoot and root growth, in particular, was significantly increased

Table 3. Shoot and root growth parameters of strawberry plants cv. ‘Selva’ treated with “Resistim”, NPK and “Resistim” + NPK, in comparison with not-fertilized plants (Control)

	Growth parameters	Treatments			
		Control	“Resistim”	NPK	“Resistim” + NPK
Shoots	Fresh matter of shoots [g]	4.75 a*	5.825 a	4.425 a	4.995 a
	Dry matter of shoots [g]	1.125 a	1.375 a	1.00 a	1.15 a
	Number of leaves	6.875 a	7.5 a	7.25 a	7.125 a
	Shoot area [cm^2]	145.655 a	159.238 a	156.268 a	152.218 a
	Shoot volume [cm^3]	138.818 a	116.176 a	116.379 a	131.699 a
	Green colour of leaves SPAD	663 a	673.75 a	704.25 a	696.75 a
Roots	Fresh matter of roots [g]	4.6875 a	6.6125 ab	5.65 ab	6.9875 b
	Dry matter of shoots [g]	1.125 a	1.375 a	1.00 a	1.15 a
	Number of root tips	1425.88 b	1360.88 b	720 a	991.25 a
	Root area [cm^2]	75.3113 b	87.8363 b	48.77 a	79.3325 b
	Root volume [cm^3]	33.97 b	39.2413 b	21.3287 a	19.9575 a
	Root diameter [mm]	0.4375 a	0.6525 b	0.6375 b	0.52375 ab
	Root length [m]	12.52 b	12.6588 b	6.91125 a	13.6125 b

*Explanations: see Table 1

by this treatment (Stępowska, 2010). Our results are consistent with the above reports, indicating a stimulating effect of “Resistim” on some of root and shoot growth parameters of the tested strawberry cultivars. However, the chlorophyll content in the leaves was not increased by the “Resistim” treatment. In our study, some of the root and shoot growth parameters were increased by the treatments with “Resistim”, confirming the beneficial properties of this product. For example, the short-day cultivar ‘Elsanta’ formed bigger and longer root system, with a greater number of root tips, as a response to “Resistim” applications in comparison with NPK basal fertilization. Similarly, compared with NPK application the cultivar ‘Selva’ also showed increased number of root tips, root area, root volume, and root length as a result of “Resistim” treatments. Stępowska (2010) reported that NPK fertilization in combination with “Resistim” increased yield and fruit quality in pepper plants. All the strawberry cultivars used in our study responded to the applications of NPK + ”Resistim” with an increase in some of plant growth parameters, in comparison with NPK fertilization. For example, extra application of “Resistim” to the NPK fertilized plants significantly increased root volume and root diameter in ‘Honeoye’, the number of root tips in 'Elsanta', root area in 'Selva' and root length in both 'Elsanta' and 'Selva' cultivars. The results obtained revealed high effectiveness of "Resistim" + NPK as compared with standard NPK fertilization in stimulating strawberry growth and development.

All the tested strawberry cultivars grown in controlled greenhouse conditions responded positively to "Resistim" applications. This product proved to be effective due to its stimulating and nutritional properties imparted by its components: a potassium salt of phosphorous acid and natural betaines.

Lovatt (1999) noticed that foliar applications of potassium phosphite significantly increased the yield of 'Navel' orange trees, fruit size and total soluble solids content. The improvement in fruit was interpreted as a response of citrus trees to increased P nutrition. Ricard (2000) reported that Phi-based P fertilizer applied to the soil or the leaves consistently improved the yield and quality of many crops, such as celery, onion, potato, peach, orange and cotton. Furthermore, it was reported that various bacteria can metabolize Phi to Pi, for example, *Escherichia coli*, *Pseudomonas stutzeri*, *Alcaligenes faecalis* and *Xanthobacter flavus* (White and Metcalf, 2007).

Phosphorus in the phosphite form (Phi) can be well absorbed by leaves and roots, but many scientists reported strong evidence questioning its utility to plants as a P fertilizer (Forster et al., 1998; Schroetter et al., 2006). Tomato and pepper plants cultivated in hydroponic cultures treated with technical Phi (prepared from phosphorous acid neutralized with KOH) showed a significant reduction in growth compared with Pi-fertilized plants (Forster et al., 1998; Varadarajan et al., 2002). Schroetter and co-workers (2006) reported that foliar applications of potassium phosphite on maize plants had no beneficial effect on the growth of maize plants in a field trial under either Pi-deficient or Pi-sufficient conditions. The same authors noticed strong inhibition in the growth (stunted growth to complete death) of maize plants treated with potassium phosphite as the sole P source via either soil or foliar applications.

Some researchers claimed that deleterious effects of Phi on plant growth resulted from inappropriate use of this product, such as the use of Phi as a sole P source or in excessive amounts (Lovatt and Mikkelsen, 2006; Watanabe, 2005). Lovatt and Mikkelsen (2006) paid attention to differences between phosphite and phosphate and the possibility of phytotoxicity of Phi forms when not used correctly. The same researchers highlighted a stimulating effect of Phi on plants that might not occur with Pi. Moreover, combinations of Phi and Pi forms of phosphorus are suggested to be more effective than either Phi or Pi alone (Young, 2004), which is in agreement with our results, where NPK standard fertilization were used together with "Resistim" application.

Most of the studies conducted under field conditions revealed positive crop responses to Phi (Albrigo, 1999;

Rickard, 2000; Watanabe, 2005), indicating the influence of Phi on the pathogens which could be threatening to strawberry plants (McDonald et al., 2001). Phi is well known as an agent effectively controlling many plant diseases, particularly *Phytophthora* sp. (Fenn and Coffey, 1984; Jackson et al., 2000; Jee et al., 2002; Smillie et al., 1989). The fungicidal effect of phosphite can be due to direct impact on the fungal pathogen and/or indirect through stimulation of the plant defense response (Jackson et al., 2000; Smillie et al., 1989). McDonald et al. (2001) suggested that the benefits of Phi application as opposed to Pi are likely to result from its fungicidal activity.

Responses of plants to phosphite fertilizer may be related to its effect on sugar metabolism, stimulation of the shikimic acid pathway, or internal hormonal and chemical changes. A significant potential of Phi-based preparations to act as phytotoxic agents and their ability to induce adverse reactions with other products in the spray tank (such as microelements and pesticides) were also reported (Thao and Yamakawa, 2009).

Potassium is a very important nutrient for plants. It is absorbed as K^+ ion (Lester et al., 2010). In our study, "Resistim" was applied as a foliar fertilizer and in this way potassium could be absorbed effectively by the plants. Supplementary nutrition in strawberries by foliar feeding is well known and practised (Deremiens, 1995). Even though the optimal fertilization could be applied to the soil before planting, foliar application is considered not only to provide an additional source of nutrients, but also helps the plant to withstand a wide range of stresses. In our work, this could refer to transplant shock. Furthermore, foliar fertilization can increase the uptake of nutrients from the soil by stimulating exudation of organic substances from the roots into the soil. The microorganisms present in the root zone are stimulated by these exudates, so their activity increases the availability of nutrients to the plants (Kuepper, 2003).

The biostimulating effect of "Resistim" could also be associated with the activity of betaines, which have osmoprotective properties, very useful in stressful conditions (Huang et al., 2000). Blunden et al. (1977) revealed cytokinin-like activity of betains. Therefore, it is suggested that the increased root growth of strawberry plants treated with "Resistim" in our experiment may also be partly related to cytokinin activity. The data obtained showed some significant differences in the plant growth response of the 'Honeoye' strawberry cultivar, whereas the other two cultivars, although they both responded positively to the treatments with "Resistim", showed less pronounced differences in plant growth. Further field research is required to establish whether the use of "Resistim" can be an efficient alternative strategy to strawberry fertilization with P and K.

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WPŁYW BIOSTYMULATORA/NAWOZU “RESISTIM” NA WZROST I ROZWÓJ ROŚLIN TRUSKAWKI

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STRESZCZENIE

W intensywnej produkcji owoców w celu uzyskania wysokich plonów konieczne jest stosowanie wysokich dawek nawozów sztucznych oraz środków ochrony roślin. Alternatywą dla wyżej wymienionych środków produkcji roślin może być zastosowanie naturalnych stymulatorów wzrostu i rozwoju roślin. Są to produkty pochodzenia naturalnego (roślinne lub zwierzęce) bezpieczne dla zdrowia ludzi i środowiska. Biostymulatory zawierają substancje czynne, takie jak: hormony roślinne, enzymy, makro- i mikroelementy, a także inne substancje stymulujące wzrost i rozwój roślin.

Nowoczesny pogląd na rolnictwo skłania do stosowania preparatów bezpiecznych dla środowiska naturalnego i zdrowia człowieka oraz mających szerokie spektrum skuteczności. Dzisiejsza oferta środków do produkcji rolniczej zawiera wiele preparatów, których zadaniem jest nie tylko dostarczanie roślinom potrzebnych mikro- i makroelementów, lecz także stymulacja ich wzrostu i ochrona przed chorobami i szkodnikami. Preparaty zawierające fosforany i fosforyny są powszechnie stosowane jako skuteczne nawozy bądź fungicydy, a także biostymulatory. Jednym z takich nawozów jest “Resistim” zawierający w swym składzie sól potasową kwasu fosforynowego oraz naturalną betainę.

Celem badań była ocena wpływu nawozu “Resistim” na wzrost i rozwój trzech odmian truskawki (*Fragaria x ananassa* Duch). W doświadczeniu badano dwie odmiany należące do grupy odmian dnia krótkiego ‘Honeoye’ i ‘Elsanta’ oraz odmianę obojętną na długość dnia – ‘Selva’. Doświadczenie założono w październiku 2008 roku w warunkach szklarniowych i prowadzono przez trzy miesiące. Rośliny rosły w rizoboksach (po dwie rośliny truskawki w jednym rizoboksie). W każdym rizoboksie znajdowało się 1,8 kg podłoża (gleba mineralna i torf w stosunku 1:1). Kombinację kontrolną stanowiły rośliny nienawożone. W kombinacji nawożonej NPK zastosowano nawożenie doglebowe NPK (N – 1,02 g, P – 1,9 g, K – 0,78 g na jeden rizoboks). “Resistim” stosowano dolistnie w stężeniach 0,2% i 0,4%. W kombinacji NPK + ”Resistim” zastosowano nawożenie doglebowe NPK (N – 1,02 g, P – 1,9 g, K – 0,78 g na jeden rizoboks) z łączną aplikacją dolistną biostymulatora “Resistim” w stężeniach 0,2% i 0,4%. Nawadnianie roślin sterowane było przez automatyczny system nawadniający. Zastosowanie rizoboksów pozwoliło na wizualizację wzrostu i rozwoju systemu korzeniowego. Otrzymane wyniki wykazały znaczące różnice w reakcji odmian truskawki po zastosowaniu preparatu “Resistim”. Odmiana ‘Honeoye’ wykazała największe różnice we wzroście pod wpływem zastosowanego nawozu. Pozostałe odmiany: ‘Elsanta’ i ‘Selva’ również pozytywnie zareagowały na preparat “Resistim”, choć jego wpływ nie był tak znaczący jak u odmiany ‘Honeoye’. Uzyskane wyniki wskazują na potrzebę dalszych badań w warunkach polowych w celu potwierdzenia korzystnego wpływu stosowania preparatu “Resistim” na wzrost, rozwój i plonowanie roślin truskawki.

Słowa kluczowe: biostymulator, wzrost roślin, truskawka, odmiana