

INFLUENCE OF THREE BIOSTYMULANTS ON YIELDING AND FRUIT QUALITY OF THREE PRIMOCANE RASPBERRY CULTIVARS

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Abstract: There was tested an influence of three biostymulants Atonik SL, Biochikol 020 PC and Tytanit on yield and fruits quality of three fruiting repeating Polish raspberry cultivars: Pokusa, Polka and Poranna Rosa during years of 2005–2006. These agents had a positive influence on fruits quality and yielding to all tested cultivars. The fruits with exception of Tytanit treated fruit especially in the beginning of harvest, were characterized by better firmness and were bigger. However, Tytanit treatment increased soluble solids content in fruits and reduced in Polka cv. nitrates concentration. Among tested cultivars, cv. Polka was characterized by the highest yield, that was of c. a. 50% greater that of cv. Pokusa, which was characterized by the greatest fruits sizes. The ‘Poranna Rosa’ shawed the least soluble solids and vitamin C content and had the highest acidity.

Key words: raspberry, biostimulant, Atonik, Tytanit, Biochikol, firmness, yield

INTRODUCTION

Common using of chemical plant protective agents and commercial fertilizers is one of reasons of the environment deterioration. There are many countries where some actions against irrational and excessive agricultural production chemicalization were taken. Chemical plant protective agents against diseases, pests or weeds should be replaced with alternative methods when it is possible as biological, physical and agricultural [Mochecki 2006]. Raspberries fruiting on one-year shoots are excellent fit to it. Outgrowing young shoots during the spring are less open on damages caused by frost and are also less paralyzed by diseases and most of pest. Fruits picked in the autumn are less wormy and include less pesticides remains.

Technologies used in plant production so far, trying improve only ways of cultivation, are not sufficient because they do not use of all variety biological potential. That is the reason for searching the best conditions to assure plant growth and development

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which will not cause the bio- and abiotic stresses. One of the possible solution is the use of the biostimulants which initiate variety biological potential which is not possible to achieve by cultivation technology. Biostimulants include hormones, enzymes, proteins, amino acids, microelements and other compounds [Kołaczyńska-Janicka 2004]. Most of biostimulants are the synthetic agents, whereas plant and alga extracts are also very popular. Usage of biostimulants at the beginning of in the vegetation makes possible to regenerate plants after the winter and quick start in the spring. Biostimulants used during flowering period help the plants to concentrate on flower development and fruit setting.

Raspberries are characterized by a very delicate fruits. There are many factors which cause reduction of fruit durability [Haffner et al. 2002, Heiberg 1988]. The most important is rotting during harvest and after harvest in packaging [Perkins-Veazie and Nonnecke 1992]. The fruit firmness progressively decreases along with ripening [Sjulin and Robbins 1987]. Intensification of unfavorable factor reduces the yield and fruit quality drastically deteriorates too. Harvesting fruits at a due time of fruit ripeness assures optimum aroma, firmness, fruit size and colour. Firmness or stone fruit mechanical resistance are considered to be a good raspberry quality indices. They show usefulness of fruits to harvest, transport, consumption or freezing and estimate fruit susceptibility to mycotic diseases infections [Rybczyński et al. 2001, Haffner et al. 2002].

The aim of the experiment was to characterize an influence of three biostimulants Atonik SL, Biochikol 020 PC and Tytanit on three fruit quality of Polish raspberry cutlivars: Pokusa, Polka and Poranna Rosa.

MATERIALS AND METHODS

The experiment was carried out in 2005–2006 at the Experimental Fruit-growing Station of the Szczecin University of Agriculture. The experimental material were three repeating fruiting raspberry varieties (*Rubus idaeus* L.) cultivated for autumn harvest: 'Polka', 'Pokusa' and 'Poranna Rosa' with yellow fruits were treated by three biostimulants: Atonik SL (0.3% sodium para-nitrophenolan, 0.2% sodium orto-nitrophenolan, 0.1% sodium 5-nitroguajakolan), Biochikol 020 PC (chitozan), Tytanit (0.8 g titanium) at the rate 0.1%, 2%, 0.04% respectively. Control plants were not sprayed. During the experiment no chemical protection of plants was used. Soon after finished fruiting shoots were cut at the ground level. The plantation was irrigated every year and fertilized with ammonium salpeter by means of a T-Tape type fixed drip system. The plants were sprayed to moisten leafs fully five times every week starting at the beginning of May. The two-factor experiment was founded by randomized split-plot method in four repeats. An area of one plot was 2.5 m² and the whole experiment's area was 160 m². The total yield mass and one fruit mass on all experimental plot every year were determined. The fruits firmness was measured right after the harvest. The content of soluble solids, vitamin C and nitrates was determined by a refractometr (Merck) whereas juice efficiency was determined after treatment the pulp with a pectinase and then squeezing by a hydraulic fruit press. The results obtained were worked out by the

two-factor variance analysis checked separately for every year. The means were verified by Duncan's test at a level of significance $\alpha = 0.05$.

RESULTS AND DISCUSSION

The most important feature describing usefulness of a cultivar for the cultivation is its yielding ability. The Polka cultivar had the highest yield among of three studied raspberry cultivars (tab. 1). The yield sum of two years was 20.85 kg of fruit from a plot. The yield of remaining cultivars were definitely lower (50% lower compared to 'Polka'). It was stated that the usage of biostimulants had a significant influence on yield increase. Spraying with Atonik SL gave the best results for the all tested cultivars. Mikos-Bielak [2004] also observed that the yield increased even by 20% after usage of Atonik SL. Also spraying with Tytanit increased the yield [Basak 2001].

Table 1. Effect of used biostimulants on raspberry yielding – sum of years 2005–2006, kg·plot⁻¹
Tabela 1. Wpływ zastosowanych bioregulatorów na plonowanie maliny – suma z lat 2005–2006, kg·poletko⁻¹

Biostimulant Bioregulator	Cultivar – Odmiana			
	Polka	Pokusa	Poranna Rosa	Mean – Średnia
Control Kontrola	18.28 e*	7.65 a	7.92 a	11.20 a*
Atonik SL	23.03 f	10.68 c	13.69 d	15.80 c
Tytanit	19.27 e	9.97 bc	10.36 c	13.20 b
Biochikol 020 PC	22.80 f	9.29 b	10.64 c	14.24 bc
Mean Średnia	20.85 b	9.40 a	10.65 a	

Means followed by the same letter or asterix do not differ significantly at $p = 0.05$ according to Duncan's multiple range test

Średnie oznaczone tą samą literą nie różnią się istotnie, wg testu Duncana, na poziomie istotności $\alpha = 0.05$.

Fruits quality is as important as yield magnitude. 'Pokusa' cultivar had definitely the greatest fruits during the whole harvest period distinct from 'Polka' with the smallest fruit size but the highest yield (tab. 2). There was an apparent positive influence of all used biostimulants on fruits size. The greatest fruits were picked from plants sprayed by Tytanit at the beginning of the harvest but at the end they were smaller than the control fruits. Tytanit caused also the greatest reduction of fruits mass at the end of harvest period as compared to the very first picking of all cultivars (57%). Control combination fruits lost the least mass (42.3%). Mikos-Bielak [2004] having used Tytanit also picked greater fruit compared to control. Carlos et al. [2003] got very similar effects on *Prunus*.

Table 2. Biostimulant effect on 100 raspbarriy fruits mass, g
Tabela 2. Wpływ zastosowanych biostymulatorów na masę 100 owoców malin, g

Biostimulant Bioregulator	Harvest beginnig – Początek zbiorów				End of a harvest – Koniec zbiorów				fruits size change zmiana wielkości owoców (%)
	'Polka'	'Pokusa'	'Poranna Rosa'	mean średnia	'Polka'	'Pokusa'	'Poranna Rosa'	mean średnia	
Control Kontrola	360 a	530 e	443 c	444 a	167 a	300 c	300 c	256 b	-42.3
Atonik SL	399 b	627 f	487 d	504 b	180 a	360 d	300 c	280 c	-44.4
Tytanit	428 bc	663 g	529 e	540 c	160 a	265 b	270 b	232 a	-57.0
Biochikol 020 PC	400 b	610 f	435 c	482 b	157 a	350 d	275 b	261 bc	-45.9
Mean Średnia	387 a	608 c	449 b		166 a	319 b	286 b		

Means followed by the same letter or asterix do not differ significantly at $p = 0.05$ according to Duncan's multiple range test

Średnie oznaczone tą samą literą nie różnią się istotnie, wg testu Duncana, na poziomie istotności $\alpha = 0,05$.

In this experiment fruit firmness was measured with petiole and soon after removal of the removed petioles. The firmness is one of the features showing cultivar's usefulness to transport. 'Pokusa' was characterized by the firmest and greatest fruits among tested varieties (tab. 2 and 3). Fruits of cultivar Poranna Rosa were very firm both with petioles and without them. Among used biostimulants, Atonik SL and Biochikol 020 PC caused the in arease of fruit firmness. Chitosan used on strawberry gave very similar effects [Hernandez-Munoz et al. 2005]. Fruit picked from bushes treated with Tytanit had alike firmness as control fruits. Carlos et al. [2003] confirmed that plum fruits sprayed by Tytanit were firmer than control fruits.

The essential influence of used biostimulants was found regarding chemical composition of particular cultivar (tab. 4). 'Polka' had the highest soluble solids content in fruits (11.1%) and the lowest acidity (1.75%). 'Poranna Rosa's' fruits had definitely the least soluble solid content (9.7%) and they were also the most acid. The content of soluble solid determined checked in fruits of 'Poranna Rosa' was definitely lower and acidity higher in comparison to cultivars tested by Ochoa et al. [1999]. It was observed that usage of Atonik SL and Biochikol 020 PC reduced the soluble solid content in fruits whereas spraying with Tytanit significantly increased. Indeed, Tytanit and Atonik SL increased acidity of fruits too.

The 'Poranna Rosa's' fruits had the least vitamin C content and were also characterized by the lowest content of the nitrates. The all tested cultivars showed higher level of nitrates in fruits harvested from plants sprayed with Atonik SL (27.4–42.4 mg·kg⁻¹ f.w.). In Poland and other countries there is a lack of regulations on permissible nitrate content in the fruit (except for bananas). However, Chemical-Agricultural Stations on the basis of previous surveys presume admissible content in strawberries 250 mg NaNO₃ per kg of fresh weight [Żurawicz 2002]. The control plants and plants treated with Atonik SL

Table 3. Firmness of the raspberry fruit - Analysis for 2005–2006, G·mm⁻¹

Tabela 3. Jędrność owoców maliny – synteza z lat 2005–2006, G·mm⁻¹

Biostimulant Bioregulator	'Polka'		'Pokusa'		'Poranna Rosa'		Mean – Średnia	
	with petiole z szypułką	without petiole bez szypułki	with petiole z szypułką	without petiole bez szypułki	with petiole z szypułką	without petiole bez szypułki	with petiole z szypułką	without petiole bez szypułki
Control Kontrola	126 C	39 bc	145 DE	52 d	57 A	28 a	109 B	40 a
Atonik SL	130 C	42 c	152 E	65 e	71 A	33 ab	118 C	47 b
Tytanit	103 B	41 c	130 C	55 d	61 A	29 a	98 A	42 a
Biochikol 020 PC	134 CD	43 c	157 E	68 e	64 A	37 bc	118 C	49 b
Mean Średnia	123 B	41 b	146 C	60 c	66 A	33 a		

Means followed by the same letter or asterix do not differ significantly at $p = 0.05$ according to Duncan's multiple range test

Średnie oznaczone tą samą literą nie różnią się istotnie, wg testu Duncana, na poziomie istotności $\alpha = 0,05$.

Means for fruits without stalks were marked by a lowercase; means for fruits with stalks were marked by a capital letter.

Małą literą oznaczono średnie dla owoców bez szypułki, dużą literą średnie dla owoców z szypułką.

Table 4. The biostimulant effect on fruit biochemical composition of three raspberry cultivars
Tabela 4. Wpływ biostymulatorów na skład chemiczny owoców trzech odmian malin

	Biostimulant Biostymulator	Cultivar – Odmiana			
		Polka	Pokusa	Poranna Rosa	mean – średnia
Soluble solids – Ekstrakt, %	control – kontrola	11.3 d	9.9 ab	9.6 a	10.3 b
	Atonik SL	10.7 c	10.1 b	9.5 a	10.1 a
	Tytanit	11.6 d	10.7 c	10.1 b	10.8 c
	Biochikol 020 PC	10.8 c	9.9 ab	9.7 ab	10.1 a
	mean – średnia	11.1 c	10.2 b	9.7a	
Acidity – Kwasowość, %	control – kontrola	1.70 a	1.98 c	2.57 e	2.08 a
	Atonik SL	1.82 b	2.11 d	2.84 f	2.26 b
	Tytanit	1.79 ab	2.10 d	2.65 e	2.18 b
	Biochikol 020 PC	1.68 a	1.95 c	2.64 e	2.09 a
	mean – średnia	1.75 a	2.04 b	2.68 c	
Vitamin C – Witamina C, mg·100g ⁻¹	control – kontrola	59 f	53 ef	42 bc	51 c
	Atonik SL	47 cde	50 de	46 cd	48 bc
	Tytanit	43 bc	45 cd	22 a	37 a
	Biochikol 020 PC	48 cde	44 cd	36 b	43 b
	mean – średnia	49 b	48 b	37 a	
Nitrates – Azotany, mg·kg ⁻¹ f.m.	control – kontrola	160 bc	157 b	121 a	146 a
	Atonik SL	382 e	424 f	274 d	360 b
	Tytanit	152 b	186 c	154 b	164 a
	Biochikol 020 PC	157 b	135 ab	109 a	134 a
	mean – średnia	213 b	226 b	165 a	

*Means followed by the same letter or asterisk do not differ significantly at p = 0.05 according to Duncan's multiple range test

*Średnie oznaczone tą samą literą nie różnią się istotnie, wg testu Duncana, na poziomie istotności $\alpha = 0,05$.

had the highest vitamin C content. However, Mikos-Bielak [2004] experiment showed that Atonik SL (Asahi) definitely lowered vitamin C content. In this experiment spraying plants with Biochikol 020 PC resulted in lower vitamin C content in comparison to the control, however, Li and Yu [2000] having used chitosan on a peach noticed that vitamin C content was higher.

CONCLUSIONS

1. 'Polka' yielded the best among three tested raspberry cultivars. Its yield was twice as high as 'Pokusa' and 'Poranna Rosa' yields. Among of tested cultivars Pokusa had the firmest and the biggest fruits.

2. the usage of biostimulants improved the yields of all tested raspberry cultivars and increased size of fruits, especially in the beginning of fruiting. Atonik SL gave the best effects, it caused the average increase of the yield by 41%.

3. Atonik SL and Biochikol 020 PC increased raspberry fruit firmness.

4. 'Poranna Rosa' fruits had the least soluble solid, nitrates, vitamin C content and had the highest acidity.

5. Tytanit increased soluble solid content in fruits compared to control variant. Tytanit and Atonik SL increased fruit acidity. Moreover Atonik SL significantly increased nitrates content in the all fruits of tested varieties.

REFERENCES

- Basak H. 2001. Stosowanie preparatu Tytanit w sadach. OWK 7, 39–40.
- Carlos A., Botia M., Alcaraz F., Riquelme F., 2003. Effects of foliar sprays containing calcium, magnesium and titanium on plum (*Prunus domestica* L.) fruit quality. J. Plant Physiol. 160, 1441–1446.
- Haffner K., Rosenfeld J.H., Skrede G., Wang L., 2002. Quality of red raspberry *Rubus idaeus* L. cultivars after storage in controlled and normal atmospheres. Posth. Biol. Technol. 24, 279–289.
- Heiberg N., 1988. Fresh fruit quality evaluation for red raspberry. Norwegian J. Agric. Sci. 2(2), 73–78.
- Hernandez-Munoz P., Almenar E., Ocio M., Gavara R., 2005. Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria x ananassa*). Posth. Biol. Technol. 39, 247–253.
- Kończyńska-Janicka M., 2004. Biostymulatory w nowoczesnej uprawie roślin, Wieś Jutra 3, 25–26.
- Li H., Yu T., 2000. Effect of chitosan on incidence of brown rot, quality and physiological attributes of postharvest peach fruit. J. Sci. Food Agric. 81 (2), 269–274.
- Mochecki J., 2006. Jak uzyskać certyfikat Integrowanej Produkcji? Ogólnopolska Konferencja Sadownicza „Nowe Odmiiany i Technologie Uprawy Krzewów Jagodowych”. Skierniewice, 27 kwietnia 2006, 41–52.
- Mikos-Bielak M., 2004. Bioregulacja plonowania i chemicznej jakości plonu malin jako efekt zastosowania Asahi. Annales UMCS, Sec. E Agricultura, 59, 3, 1471–1479.

- Ochoa M. R., Kessler A. G., Vullioud M. B., Lozano J. E., 1999. Physical and Chemical Characteristics of Raspberry Pulp: Storage Effect on Composition and Color. *Lebensm.-Wiss. u.-Technol.* 32, 149–153.
- Perkins-Veazie P.M., Nonnecke G.R., 1992. Physiological changes during ripening of raspberry fruit. *Hort. Sci.* 27, 331–333.
- Rybczyński R., Dobrzański jr., B., Wieniarska J., 2001. Właściwości mechaniczne owoców maliny. *Acta Agrophysica* 45, 167–175.
- Sjulin T.M., Robbins J.A., 1987. Effects of maturity, harvest date, and storage time on postharvest quality of red raspberry fruit. *J. Amer. Soc. Hort. Sci.* 112, 3, 481–487.
- Żurawicz E., 2002. Proekologiczne technologie produkcji owoców. Integrowana produkcja owoców truskawki. Skierniewice 64 pp.

WPLYW STOSOWANIA TRZECH BIOPREPARATÓW NA PLON ORAZ JAKOŚĆ OWOCÓW TRZECH ODMIAN MALIN

Streszczenie: W latach 2005–2006 określono wpływu trzech bioregulatorów, Atonic, Biochikol 020 PC i Tytanit, na plon oraz jakość owoców trzech powtarzających owocowanie polskich odmian malin: Pokusa, Polka i Poranna Rosa. Zastosowane środki u wszystkich badanych odmian wpłynęły pozytywnie na plonowanie i jakość owoców. Owoce roślin traktowanych bioregulatorami (z wyjątkiem stosowania Tytanitu), zwłaszcza na początku zbiorów, były większe oraz jędrniejsze. Zastosowanie Tytanitu przyczyniło się natomiast do zwiększenia zawartości ekstraktu w owocach i zmniejszenia, u odmiany Polka, koncentracji azotanów. Spośród trzech przebadanych odmian najlepiej plonowała odmiana Polka, plon był o 50% większy, natomiast największymi owocami charakteryzowała się Pokusa. Żółte owoce Porannej Rosy zawierały najmniej ekstraktu i witaminy C i miały największą kwasowość.

Słowa kluczowe: malina, biostymulatory, Atonik, Tytanit, Biochikol, jędrność owoców, plon

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