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EFFICIENCY OF CUCUMBER (*Cucumis sativus* L.) POLLINATION BY BUMBLEBEES (*Bombus terrestris*)

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Abstract. The cucumber crop size depends not only on the cultivar and agrotechnical conditions but also on proper pollination of flowers. The aim of the work was the investigation of the efficiency of bumblebees used in the cultivation of cucumber on the yield, physical parameters and chemical traits of fruits. The investigations were performed on two cucumber cultivars Pavlina F_1 and Natasia F_1 obtained from Seminis company. It was established as a three factor experiment in four replications. The bumblebees from the Koppert company was introduced to the cucumber cultivation two times. Marketable yield, the numbers of flowers and fruits as well as physical and chemical traits were investigated. Marketable yield of fruits from the treatment with bumblebees was at the similar level with marketable yield from the control treatment with significantly higher number of fruits in the bumblebees treatment. The yield of fruits of the first class was at the similar level in both treatments with significantly higher number of fruits in the control treatment. A higher firmness and better quality were characteristic for fruits in the treatments with bumblebees than from the control treatment. A higher nitrate content was characteristic for fruits from the control treatment and fruits from the second and third term of planting. A higher phosphorus content was noted in fruits from the treatment with bumblebees in the first and third term of cultivation and in fruits of the Pavlina F_1 cultivar.

Key words: term of planting, pollination, yield, physical traits, chemical compositions

INTRODUCTION

Pollination plays an important role in flowering plant reproduction and fruit set for wild plant communities [Corbet et al. 1991, Buchmann and Nabhan 1996]. Estimates showed that up to 90% of all flowering plant species rely on pollination by insects such as bees [Richards 1986, Buchmnn and Nabhan 1996]. The low fruit set can be due to a lack of honey bees, or to some biotic and abiotic stress. Unfavorable environmental

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conditions such as high or low temperature, drought and low irradiance can cause the abortion of flower buds in pumpkin and others crops [Wien 1997, Kalbarczyk 2009]. The absence of sufficient pollinators can result in low fruit yield and reduced fruit size [Walters and Taylor 2006]. Thus it is recommended to use hives with honey-bees in the case of cucumber cultivation [Gingeras at al. 1999] or as it was in this case hives with bumblebees. The greatest benefits from the use of those insects is the yield increase and quality improvement [Dobromilska and Fawcett 1999]. Bumblebees, as compared to honey-bees begin their flights at the lower temperature (about 11°C) and during one hour they visit a bigger number of flowers. They comprise the most numerous group of pollinating insects which most often choose female flowers while visiting plants from the pumpkin family which leads to their better pollination [Dmitruk 2006, Shin at al. 2007, Kowalska 2008]. The size of bumblebees also causes the fact that they may carry more pollen, thus better pollinate flowers of vegetable plants than honey-bees [Stanghellini at al.1997].

The aim of this work was the investigation of the efficiency of bumblebees used in the cultivation of cucumber on the yield, physical parameters and chemical traits of fruits.

MATERIAL AND METHODS

The investigations were performed on two cucumber cultivars Pavlina F_1 i Natasia F_1 obtained from Seminis Vegetable Seeds Polska sp. z o.o. The experiment was carried out on the Experimental Plots of the Department of Vegetables and Medicinal Plants of Warsaw University of Life Sciences – SGGW in the years 2008 and 2009. Field experiment was established in the random block system as a three factor experiment in four replications. The first order factor was a treatment with bumblebees (the introduction of bumblebees from the Koppert company to the cucumber cultivation was on 23 June and 4 August in 2008 and on 24 June and 6 August in 2009) and the control treatment. Seeds were sown 12 May, 28 May and 9 June in 2008 and 30 April, 14 May and 28 May in 2009, to plastic pots with 8 cm in diameter filled with peat substrate. The second order factor was the term of seedling planting: I – 4 June, II – 18 June, and III – 30 June in 2008 and I – 21 May, II – 4 June, and III – 18 June in 2009.Seedlings were planted on the field when the plants had 2–3 leaves. Planting density was 40×100 cm. There were 14 plants in the plot. The third order factor was the cultivar. Average temperatures and rainfall sums were recorded (tab. 1). Plants were grown in deep medium-heavy alluvial soil with a 1.9–2.3% content of organic matter. Owing to good texture, the air-water conditions of the soil were satisfactory for plant production and during the period of water shortage plants were T-Tape irrigated. The soil content of N, P, K, and Mg was kept at the optimum level with fertilizers applied to equal the average of 150 kg $N \cdot ha^{-1}$ (60 kg N side dressing), 50 kg $P \cdot ha^{-1}$, and 190 kg $K \cdot ha^{-1}$. The harvest of fruit lasted from the end of July in 2008 and 2009 until the middle of September in both years. Marketable fruits were graded according to the Polish standard PN-85/R-75359 into the following two classes: pickling grade: 6–10 cm long with a diameter of 2.5–4.5 cm, pickling

grade: 9–15 cm long with a diameter of 4.5–5.5 cm. Physical properties were determined and chemical analyses of cucumber fruit were performed.

Table 1. Average temperatures and the sums of rainfall for May-September in the years 2008–2009
Tabela 1. Średnie dobowe temperatury powietrza i sumy opadów od maja do września w latach 2008–2009

Months Miesiące	Temperatures Temperatura, °C		Long-term means of temperatures Średnia temperatura wieloletnia, °C	Rainfall Opady, mm		Long-term sums of rainfall Opady – sumy wieloletnie, mm
	2008	2009	1931–1990	2008	2009	1931–1990
May May	14.1	13.9	13.7	36.8	82.4	58.1
June Czerwiec	19.3	16.3	16.9	24.5	123.1	67.8
July Lipiec	19.7	20.2	18.1	97.5	123.3	66.5
August Sierpień	19.2	18.5	17.6	89.0	82.7	65.7
September Wrzesień	13.0	15.5	13.5	53.7	13.9	43.1

Fruit firmness – the measurements were taken using Instron 4303 apparatus. Firmness was defined as a value of force necessary for puncturing fruit skin with a 7 mm cylindrical probe. Measurements were taken with the crosshead 500 $N \cdot cm^{-2}$ moving at the speed of 200 $mm \cdot min^{-1}$. The results were expressed in $N \cdot cm^{-2}$.

The fruit quality was evaluated by the contents of basic macro-components: NO_3 determined by the flow method with the wave length of 560 nm, P was determined by the spectrophotometric method with the wave length of 460 nm, K, and Ca by the flame method using the flame photometer.

Statistical analysis was elaborated using a three-way analysis of variance. A detailed comparison of means was performed applying the Tukey's test at the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

The use of pollinating insects, especially bumblebee in plant cultivation allows obtaining a higher yield of fruits even in bad atmospheric conditions, which may induce cucumber producers to use those insects [Spiżewski 2005, Kalbarczyk 2007]. Results of the investigations show that a higher number of female flowers was characteristic for the control treatment as compared with the treatment with bumblebees. The highest number of flowers was obtained from the first term of cultivation, however, no significant differences were observed in the number of flowers between cultivars (tab. 2).

Despite a bigger number of female flowers and higher number of fruit in the marketable yield in the control treatment (tab. 2, 4) it was noted that the fruit yield was at

a comparable level in both treatments used (tab. 3) which shows that the presence of bumblebees had a positive effect on the filling and quality of cucumber fruits. The results of studies carried out by Abak et al. [1995], Stępowska [1996] as well as Dobromilska [1997] confirmed influence of bumblebee on the heavier and better quality fruits.

Table 2. The number of female flower in cucumber, pcs.·plant^{-1} (2008–2009)
Tabela 2. Liczba kwiatów żeńskich u ogórka, szt.·rośl.$^{-1}$ (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	60.2 a*	54.7 a	47.7 a
	Natasia F_1	53.7 a	44.5 a	44.2 a
Control Kontrola	Pavlina F_1	85.2 a	45.7 a	50.7 a
	Natasia F_1	86.0 a	48.7 a	55.0 a
Mean for treatment Średnia dla kombinacji	Bumblebees 50.8 b Control 61.9 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 71.3a II – 48.4 b III – 49.4 b			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 57.42 Natasia F_1 55.38			

*means followed by the same letters are not significantly different at $\alpha = 0.05$ – średnie oznaczone tymi samymi literami są nieistotne statystycznie przy $\alpha = 0,05$

Table 3. The marketable yield, kg·m^{-2} (2008–2009)
Tabela 3. Plon handlowy, kg·m^{-2} (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	4.91 b*	8.35 b	7.00 b
	Natasia F_1	4.74 b	11.48 ab	13.18 a
Control Kontrola	Pavlina F_1	12.21 ab	11.47 ab	9.04 b
	Natasia F_1	8.47 b	8.32 b	7.35 b
Mean for treatment Średnia dla kombinacji	Bumblebees 8.27 a Control 9.47 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 7.56 b II – 9.90 a III – 9.14a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 8.83 a Natasia F_1 8.92 a			

*see table 2 – patrz tabela 2

Significant differences in the marketable yield were obtained between the terms of cultivation with similar number of fruits in those terms. The higher marketable yield was noted on the second and third term of cultivations than in the first one (tab. 3, 4). No significant differences were observed between cultivars in the marketable yield (tab. 3).

It was proved in the investigations by Woyke [1989] that pollinating insects, including bumblebees, have a significant effect on fruit quality in particular classes. This ob-

servation is in agreement with results obtained by Kowalska [2008]. This author noted that fruits set with a help of bumblebee ripened earlier and were heavier than those harvested from control object. It was noted that using bumblebees in the cultivation a higher fruit quality in the first class was obtained which are most needed by the producers. However, no significant effect was observed of the pollinating insects on the quality of the second class. The obtained results of the investigations show that the yield of the first class fruits did not significantly differ between treatments with the significantly higher number of fruits in the control treatment (tab. 5, 6). A higher yield of the first class was characteristic for the second and third term of cultivation as compared with the first term (tab. 5). No significant differences in the yield were observed between cultivars with a higher number of fruits in the Natasia F_1 cultivar (tab. 5, 6).

Table 4. The number of fruit in marketable yield, pcs.·plant^{-1} (2008–2009)
Tabela 4. Liczba owoców w plonie handlowym, szt.·rośl.$^{-1}$ (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	40.5 c	41.0 c	45.7 b
	Natasia F_1	39.2 c	48.2 b	40.7 c
Control Kontrola	Pavlina F_1	71.2 a	46.7 b	51.7 b
	Natasia F_1	39.7 c	46.6 b	43.4 c
Mean for treatment Średnia dla kombinacji	Bumblebees 42.5 b Control 49.9 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 47.6 a II – 45.6 a III – 45.4 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 49.5 a Natasia F_1 43.0 b			

*see table 2 – patrz tabela 2

Table 5. The marketable yield of first class of fruit, kg·m^{-2} (2008–2009)
Tabela 5. Plon handlowy owoców w I wyborze, kg·m^{-2} (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	3.58 c	7.96 b	4.93 c
	Natasia F_1	3.63 c	9.30 ab	10.90 a
Control Kontrola	Pavlina F_1	7.35 b	6.94 b	7.75 b
	Natasia F_1	6.45 b	6.74 b	5.25 b
Mean for treatment Średnia dla kombinacji	Bumblebees 6.71 a Control 6.74 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 5.25 b II – 7.73 a III – 7.20 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 6.41 a Natasia F_1 7.04 a			

*see table 2 – patrz tabela 2

Table 6. The number of fruit in first class in marketable yield, pcs.·plant^{-1} (2008–2009)
Tabela 6. Liczba owoców I wyboru w plonie handlowym, szt.·rośl.$^{-1}$ (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees	Pavlina F_1	19.1 c	36.9 ab	21.5 c
Trzmiele	Natasia F_1	19.9 c	35.4 ab	36.6 ab
Control	Pavlina F_1	36.0 ab	32.1 b	33.6 b
Kontrola	Natasia F_1	39.7 a	36.6 ab	23.4 c
Mean for treatment Średnia dla kombinacji	Bumblebees 28.2 b Control 33.6 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 28.7 b II – 35.2 a III – 28.8 b			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 29.9 b Natasia F_1 31.9 a			

*see table 2 – patrz tabela 2

Table 7. The marketable yield of second class of fruit, kg·m^{-2} (2008–2009)
Tabela 7. Plon handlowy owoców w II wyborze, kg·m^{-2} (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees	Pavlina F_1	1.11 b	0.22 c	1.57 b
Trzmiele	Natasia F_1	0.95 c	1.32 b	1.58 b
Control	Pavlina F_1	3.34 a	3.87 a	1.14 b
Kontrola	Natasia F_1	1.89 b	1.35 b	1.69 b
Mean for treatment Średnia dla kombinacji	Bumblebees 1.25 b Control 2.21 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 1.82 a II – 1.69 ab III – 1.49 b			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 1.87 a Natasia F_1 1.46 a			

*see table 2 – patrz tabela 2

Table 8. The number of fruit in second class in marketable yield, pcs.·plant^{-1} (2008–2009)
Tabela 8. Liczba owoców II wyboru w plonie handlowym, szt.·rośl.$^{-1}$ (2008–2009)

Treament Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees	Pavlina F_1	6.3 bc	3.2 c	7.2 b
Trzmiele	Natasia F_1	4.9 c	7.1 b	7.6 b
Control	Pavlina F_1	12.4 ab	14.5 a	5.8 bc
Kontrola	Natasia F_1	5.4 bc	6.1 bc	7.8 b
Mean for treatment Średnia dla kombinacji	Bumblebees 6.0 b Control 8.7 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 7.2 a II – 7.7 a III – 7.1 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 8.2 a Natasia F_1 6.5 b			

*see table 2 – patrz tabela 2

A higher yield of the second class and a higher number of fruits for the control treatment than from the treatment with bumblebees were characteristic. The highest yield of the second class was obtained in the first term of cultivation with comparable number of fruits for all the terms. No significant differences in the yield of the second class between cultivars with a bigger number of fruits for Pavlina F_1 cultivar were observed (tab. 7, 8).

Fruit firmness could be affected, among others, by such traits as the fruit size and climatic and agrotechnic conditions in plant cultivation [Guerra and Casquero 2008]. The results of the investigations show that a higher firmness was characteristic for the treatment with bumblebees as compared to the control treatment. Obtaining a higher firmness of fruits in the treatment with bumblebees points to their better quality and usefulness for food industry. Fruits picked in the third term of cultivation showed the highest firmness, however, there were no significant differences in fruit firmness between cultivars (tab. 9).

Table 9. Firmness of fruit, $N \cdot cm^{-2}$ (2008–2009)
Tabela 9. Jędrność owoców, $N \cdot cm^{-2}$ (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	79.7 ab	78.6 b	91.7 a
	Natasia F_1	87.6 ab	84.6 ab	92.7 a
Control Kontrola	Pavlina F_1	72.4 b	80.2 ab	81.5 ab
	Natasia F_1	66.7 c	77.9 b	81.2 ab
Mean for treatment Średnia dla kombinacji	Bumblebees 85.8 a Control 76.65 b			
Mean for term of cultivation Średnia dla terminu uprawy	I –76.6 b II – 80.3 ab III – 86.7 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 80.6 a Natasia F_1 81.7 a			

*see table 2 – patrz tabela 2

Table 10. The content of nitrates (NO_3), $mg \cdot 100\ g^{-1}$ f.m. (2008–2009)
Tabela 10. Zawartość azotanów, $mg \cdot 100\ g^{-1}$ ś.m. (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	1.03 d	2.13 cd	1.46 d
	Natasia F_1	3.17 c	4.12 c	2.06 cd
Control Kontrola	Pavlina F_1	1.64 d	6.63 b	9.38 a
	Natasia F_1	1.63 d	6.74 b	9.25 a
Mean for treatment Średnia dla kombinacji	Bumblebees 2.32 b Control 5.87 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 1.86 b II – 4.91 ab III – 5.53 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 3.71 b Natasia F_1 4.49 a			

*see table 2 – patrz tabela 2

Table 11. The content of phosphorus, mg·100 g^{-1} f.m. (2008–2009)
Tabela 11. Zawartość fosforu, mg·100 g^{-1} ś.m. (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	32.8 b	32.2 b	39.1 a
	Natasia F_1	34.8 b	30.1 b	32.8 b
Control Kontrola	Pavlina F_1	36.3 ab	31.9 b	34.1 b
	Natasia F_1	30.7 b	25.2 c	25.5 c
Mean for treatment Średnia dla kombinacji	Bumblebees 33.6 a Control 30.6 b			
Mean for term of cultivation Średnia dla terminu uprawy	I – 33.6 a II – 29.8 b III – 32.8 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 34.4 a Natasia F_1 29.8 b			

*see table 2 – patrz tabela 2

Table 12. The content of potassium, mg·100 g^{-1} f.m. (2008–2009)
Tabela 12. Zawartość potasu, mg·100 g^{-1} ś.m. (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	240 b	236 b	240 b
	Natasia F_1	234 b	223 c	240 b
Control Kontrola	Pavlina F_1	217 c	255 a	263 a
	Natasia F_1	236 b	228 c	205 c
Mean for treatment Średnia dla kombinacji	Bumblebees 235 a Control 234 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 231 a II – 235 a III – 237 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 241 a Natasia F_1 227 b			

*see table 2 – patrz tabela 2

Table 13. The content of calcium, mg·100 g^{-1} f.m. (2008–2009)
Tabela 13. Zawartość wapnia, mg·100 g^{-1} ś.m. (2008–2009)

Treatment Kombinacja	Cultivar Odmiana	Term of cultivation – Termin uprawy		
		I	II	III
Bumblebees Trzmiele	Pavlina F_1	27.6 a	25.8 b	26.2 ab
	Natasia F_1	26.2 ab	25.3 b	26.7 ab
Control Kontrola	Pavlina F_1	24.5 b	27.6 a	28.0 a
	Natasia F_1	27.6 a	28.0 a	28.0 a
Mean for treatment Średnia dla kombinacji	Bumblebees 26.3 a Control 27.2 a			
Mean for term of cultivation Średnia dla terminu uprawy	I – 26.4 a II – 26.6 a III – 27.2 a			
Mean for cultivar Średnia dla odmiany	Pavlina F_1 26.6 a Natasia F_1 26.9 a			

*see table 2 – patrz tabela 2

According to the recommendation of the law gazette (Dz.U. from the year 2010, Nr 201, pnt. 1330.) the content of nitrates in the cucumber fruits should not exceed 400 mg·kg^{-1} fresh matter of fruits. The obtained results of the investigations show that fruits from the control treatment were characterized by a higher content of nitrates than fruits from the treatment with bumblebees. A significant effect on the nitrate content had the cultivation term. The highest nitrate content was noted in the third term of cultivation and the lowest on the first term of cultivation. The differences in the nitrate content in fruits were also observed between cultivars. The higher content was characteristic for Natasia F_1 cultivar than Pavlina F_1 cultivar (tab. 10). It should also be stressed that the content of nitrates in cucumber fruit was at a very low level and did not exceed the value reported in the law gazette for those fruits.

It was noted in the investigations by Geissler [1979] and Grzeszczuk [2003, 2003a] that the content of phosphorus in fruits of pumpkin plants may depend on the term of cultivation and the cultivar. The obtained results of the investigations show that the content of phosphorus in fruits depended not only on the cultivation term and the cultivar but also on the treatment applied. A higher content of phosphorus was obtained in fruits from the treatment with bumblebees than from the control treatment. Phosphorus content in fruits from the first and third term of cultivation was higher than from the second term. Fruits of Pavlina F_1 cultivar were characterized by a higher phosphorus content than fruits of Natasia F_1 cultivar (tab. 11). Potassium content in fruits was at similar levels for all the investigated treatments and terms of cultivation. A higher potassium content was observed in fruits of Pavlina F_1 cultivar than in Natasia F_1 cultivar (tab. 12). The content of calcium was not affected by any of the investigated factors of the experiment (tab. 13).

CONCLUSIONS

1. Marketable yield of fruits from the treatment with bumblebees was at a similar level as the control treatment with a significantly higher number of fruits latter.

2. The yield of fruits in the first class was at the comparable level in both treatments with a significantly higher number of fruits in the control treatment. In the second class both the yield and number of fruits were higher in the control treatments. The presence of bumblebees positively affected the yield size in the first class but it affected the yield size in the second class to a smaller degree.

3. The use of bumblebees in the cucumber cultivation significantly affected the fruit firmness. A higher firmness and better quality were characteristic for fruits from the treatment with bumblebees than from the control treatment.

4. A higher content of nitrates was characteristic for fruits from the control treatment and fruits from the second and third term of cultivation, however, those values were at a very low level as compared with the Polish standards for cucumber.

5. The content of phosphorus was significantly affected by all factors of the experiment. A higher content of phosphorus was noted in fruits from the treatment with bumblebees from the first and third term of cultivation and in fruits of Pavlina F_1 cultivar.

6. The contents of potassium and calcium in cucumber fruits were at a similar level irrespectively from the applied treatment, term of cultivation and cultivar.

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EFEKTYWNOŚĆ ZAPYLANIA TRZMIELA ZIEMNEGO (*Bombus terrestris)* W UPRAWIE OGÓRKA POLOWEGO (*Cucumis sativus* L.*)*

Streszczenie: Wielkość plonu ogórka zależy nie tylko od odmiany i warunków agrotechnicznych, ale także od odpowiedniego zapylenia kwiatów. Celem pracy było zbadanie efektywności trzmieli w uprawie ogórka polowego na plonowanie, parametry fizyczne i skład chemiczny owoców. Do badań wzięto dwie odmiany ogórka polowego Pavlina F_1 i Natasia F_1 firmy Seminis. Doświadczenie założono jako trzyczynnikowe (1 – kombinacja, 2 – termin sadzenia, 3 – odmiana) w czterech powtórzeniach. Do uprawy ogórka wprowadzono dwukrotnie trzmiele z firmy Koppert. Dokonano oceny plonu handlowego, określono liczbę kwiatów i owoców oraz cechy fizyczne i chemiczne owoców. Plon handlowy owoców z kombinacji z trzmielami był na zbliżonym poziomie z plonem handlowym owoców z kombinacji kontrolnej przy istotnie większej liczbie owoców w tej kombinacji. Plon owoców pierwszego wyboru był na porównywalnym poziomie w obu kombinacjach przy istotnie większej liczbie owoców w kombinacji kontrolnej. Wyższą jędrnością i lepszą jakością charakteryzowały się owoce z kombinacji z trzmielami niż owoce z kombinacji kontrolnej. Wyższą zawartość azotanów wykazano w owocach pochodzących z kombinacji kontrolnej oraz w owocach z drugiego i trzeciego terminu uprawy. Większą zawartość fosforu stwierdzono w owocach z kombinacji z trzmielami, w pierwszym i trzecim terminie uprawy i w owocach odmiany Pavlina F_1.

Słowa kluczowe: termin sadzenia, zapylanie, plon, jakość owoców, cechy fizyczne, skład chemiczny

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