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EFFECT OF INTENSITY OF BROAD BEAN PROTECTION WITH BIOPREPARATIONS AGAINST FUNGAL DISEASES

Summary

The aim of the study was to compare the health status of biologically protected broad bean sprouts, taking into account differentiated number of biopreparation applications. The field experiments were carried out in the years 2010–2012 at the Agricultural Experimental Farm in Prusy, near Krakow. Evaluation of fungal diseases severity was performed in a 5-point scale in broad bean phase BBCH (70–79). The study demonstrated that hydrothermal conditions significantly modified the occurrence and severity of fungal diseases in broad beans. Windsor White broad bean variety, unlike Hangdown White, is significantly more infested by Botrytis fabae (leaves and pods), and pods also by Uromyces fabae (rust). An increased intensity of broad beans protection using biopreparations reduces the severity of fungal diseases occurrence during the growing season. A significant limitation in chocolate blotch development on the leaves, stems and pods, as well as rust and gray mold on pods, is provided by treatment of the broad beans with Polyversum WP biopreparation, and five times foliar application of natural preparations (4 × Bioczos BR + 1 × Biosept 33 SL) during the growing period. Applied biological protection proved to be little effective in broad bean protection against ascochytosis (A. fabae).
***Key words**: broad bean, biological protection, fungal diseases*

WPŁYW INTENSYWNOŚCI OCHRONY BOBU BIOPREPARATAMI PRZED CHOROBAMI GRZYBOWYMI

Streszczenie

Celem pracy było porównanie stanu zdrowotnego roślin bobu chronionego biologicznie z uwzględnieniem zróżnicowanej liczby aplikacji biopreparatów. Badania polowe prowadzono w latach 2010-2012 w Rolniczym Gospodarstwie Doświadczalnym w Prusach k. Krakowa. Ocenę występowania nasilenia chorób grzybowych przeprowadzono w skali pięciostopniowej w fazie BBCH (70-79) bobu. Badania wykazały, że warunki hydrotermiczne istotnie modyfikują występowanie i nasilenie chorób grzybowych bobu. Odmiana bobu Windsor Biały przeciwieństwie do Hangdown Biały jest istotnie silniej porażana przez Borytis fabae (liście i strąki), a strąki także przez Uromyces fabae (rdza). Zwiększenie intensywności ochrony bobu biopreparatami ogranicza nasilenie występowania chorób grzybowych w okresie wegetacji. Istotne ograniczenie rozwoju czekoladowej plamistości na liściach, pędach i strąkach oraz rdzy i szarej pleśni na strąkach zapewnia zaprawianie nasion bobu biopreparatem Polyversum WP i pięciokrotna nalistna aplikacja w okresie wegetacji preparatów naturalnych (4 x Bioczos BR + 1 x Biosept 33 SL). Zastosowana biologiczna ochrona okazała się mało skuteczna w ochronie bobu przed askochytozą (Ascochyta fabae).
***Słowa kluczowe**: bób, ochrona biologiczna, choroby grzybowe*

1. Introduction

In Poland, broad bean is grown as a vegetable on a small scale. However, high palatability of this plant seeds, content of protein, minerals, vitamins A, C, and carbohydrates, cause an increasing interest in broad bean cultivation [14]. Broad bean, like field bean, is infected by the pathogenic fungi such as *Botrytis fabae* Sard. (chocolate blotch), *Botrytis cinerea* Pers. Fr. (gray mold) and *Ascochyta fabae* (ascochytosis) during the growing season [2, 9, 17, 18, 24]. Broad beans rust is also a common disease, but of minor significance, and it is caused by an obligate pathogen *Uromyces fabae* [5]. According to the studies of many authors [7], these diseases occurrence during the growing season is the cause of lower yield of broad bean seeds and its deteriorated quality [18, 24].

The basis for plants protection against the pests in organic farming is properly applied agricultural technology, including quality of seed material, proper crop rotation, proper selection of varieties, rational fertilization and proper sowing and harvesting time, sowing density. These measures are not always sufficient, further direct fight against pathogens often becomes necessary [22, 23]. In recent years, an increasingly importance in plants protecting against the pests is attributed just to biological control [19]. This method is environmentally and human friendly. Biological protection, as opposed to chemical one, prevents, inter alia, pest immunization, promotes biodiversity, and seed yield is free of chemical protection agents. According to many authors [3, 10, 21, 25] the contribution of biological methods in plants protection is low. It results from the fact that no effective biological methods have been developed so far for the control or limitation of the most important plant diseases (powdery mildew of cereals and grasses, rust, septoria, fusariosis, and roots rot diseases). Moreover, the efficacy in case of most biopesticides is lower, and their application more difficult and more troublesome than chemicals. However, having in mind food safety, its quality and the health of consumer and environment, biopreparations are recommended in plants protection of against the pests. Biopreparations are plant protection products based on natural compounds of plant origin or microorganisms [19]. There is little research in the range of broad beans biological protection against fungal diseases in the literature available.

The aim of the study was to compare the health status of stems, leaves and pods of biologically protected broad bean, taking into account the differentiated number of biopreparations application.

2. Material and methods

The field experiments were carried out in 2010–2012 at the Agricultural Experimental Farm in Prusy near Cracow. Two-factor experiments were established using the method of randomized block design with 3 replications on the soil of a very good wheat complex. The first experimental factor was broad beans variety (Windsor White, Hangdown White), and the second this plant protection (a/ control; b/ seeds treatment with Polyversum WP biological preparation; c/ Polyversum WP + 3 × foliar application of biological preparations, d/ Polyversum WP + 4 × foliar application of biological preparations, e/ Polyversum WP + 5 × foliar application of biological preparations). The size of plot for observation and harvest was 20 m^2.

Windsor White is a moderately early variety (aimed for an earlier use), and Hangdown White is intended for later use, including the processing. Before sowing, the seeds of both broad bean varieties, except the control plot, were treated with biological preparation Polyversum WP at a dose of 10 g/kg of seeds. The seeds were sown in the first decade of April at a depth of 6 cm, with 50 cm spacing between rows, and 10 cm within the row. Cultivation of the soil and fertilizer was applied in accordance with the requirements and principles of organic farming. Broad bean was mechanically protected against weeds during the growing season. In contrast, diseases and pests were controlled using the following combinations of biological protection:

K1 – control (without protection),
K2 – seeds treatment Polyversum WP (a. s. 10^6 oospor *Pythium oligandrum* in 1 g of the center), at a dose 1 g in 2 l of water,
K3 – seeds treatment Polyversum WP+ 2×Bioczos BR+1×Biosept 33 SL,
K4 – seeds treatment Polyversum WP+ 3×Bioczos BR+1×Biosept 33 SL,
K5 – seeds treatment Polyversum WP + 4×Bioczos BR+1×Biosept 33 SL.

The preparation Biosept 33 SL (a. s. 33% grapefruit fruit extract) at a dose of 2 l/ha was foliar agent applied to reduce fungal diseases just before plants flowering. In turn, Bioczos BR (a. s. 10 g of garlic pulp in a shell of paraffin on one ankle) at a dose of 4 cubes/l of water was used when first aphids appeared, and against diseases and broad bean weevil at the time of withering of the first row of broad beans inflorescences. The dosage of this preparation was repeated every 7 days.

Health status of 25 plants randomly collected from the plot was evaluated during the BBCH (70–79) development phase of broad bean. The occurrence of particular fungal diseases on leaves, stems and pods was rated using the 5-point scale (1–5), expressing an increasing plants infestation. The results are presented as an infestation index (ip %) [26], and subjected to analysis of variance, and the significance of mean differences was verified using Tukey's test at $\alpha = 0.05$.

3. Results and discussion

A number of diseases can be observed on broad bean plants, but not all of them are equally significant. During the study period, the broad bean was mainly infested by chocolate blotch (B. fabae) and ascochytosis (A. fabae), and the presence of fusariosis (Fusarium spp.) was also reported on shoots, rust (Uromyces viciae fabae) and gray mold (B. cinerea) on the pods.

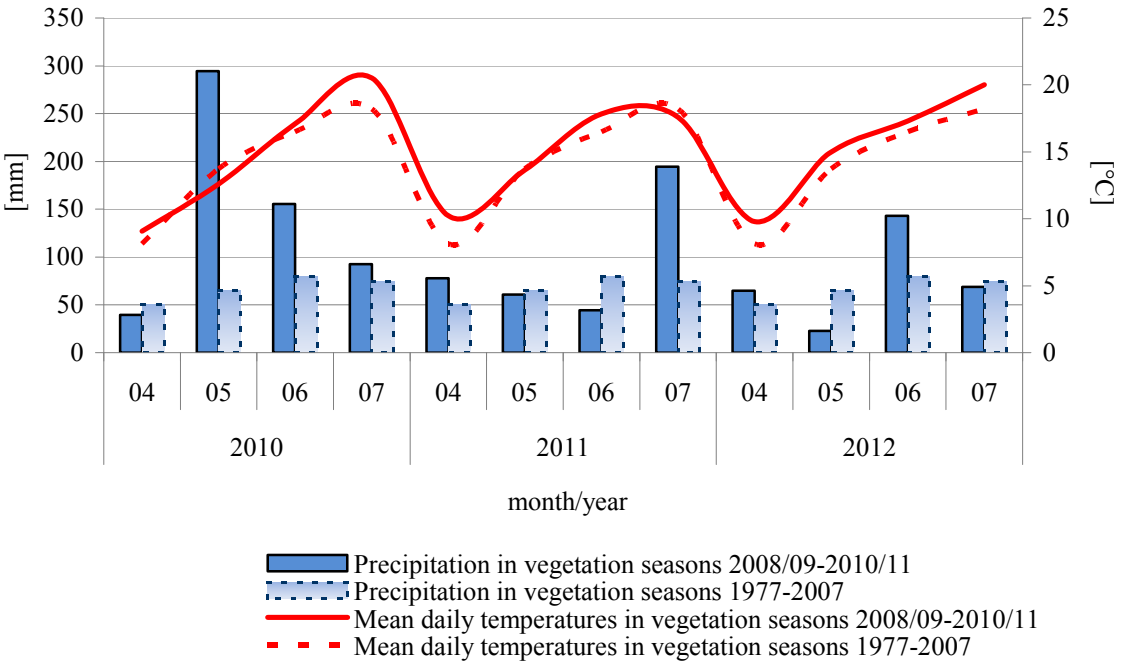
Weather conditions in the analyzed years of the study (2010–2012) (Fig. 1) affected the health status of examined plants. Generally, during the study period from April to July, year 2010 can be considered very moist (582.3 mm of precipitation) with an average air temperature of 14.8°C, while year 2012 was warmer (15.5°C) and drier (299.3 mm of precipitation). With respect to multi-year data, May, June and July 2010 were characterized by an excessive moisture. In this growing season, especially May was distinguished by the greatest sum of precipitation (294.6 mm) and was the coldest (average temperature 12.6°C). In 2011, the sum of precipitation from April to July was 377.4 mm. However, the beginning and end of broad bean growing season (April, July) this year (2011) was characterized by an excessive moisture, especially July (194.4 mm). An average temperature (17.6°C) in this most humid month was lower than in the multi-year period (18.2°C). In turn, broad bean growing season (April–July) in the year 2012 was characterized by moisture deficiency in May (22.8 mm) and July (68.7 mm). The amount of precipitation in May was threefold lower than in the multi-year period (for this month). In 2012, the only increase in moisture was recorded in June (143.1 mm of precipitation).

According to Olszewska [15], Fabaceae plants require from 300 to 450 mm of precipitation during the growing season for their proper development. Both an excess and deficiency of precipitation adversely affect the yield and the health status of these plants. According to Chmura et al. [4] and Podleśny [16], diseases development is promoted in particular by an excess of precipitation. The distribution of precipitation during this study was uneven. An excess of precipitation, both with respect to multi-year data and other years (2011 and 2012), was recorded in May and June 2010. In turn, the beginning and end of broad beans growing season (April, July) in 2011, was characterized by an excessive moisture. During the observations, July 2010 can be considered to be warmer and drier. In turn, the same month in 2011 was wetter and cooler.

Comparing the data to the multi-year data, uneven distribution of precipitation was observed during broad bean growing season from April to July, which affected the health status of these plants.

In was found in this study, that regardless of the applied plant protection, the years significantly affected an index of all parts of the plant infestation by pathogenic fungi (Table 1). Especially significant diseases increase in broad bean was recorded in 2012, which was the warmest and driest, despite an excessive moisture recorded in April. However, the next month of this year (2012) – May, was characterized by 3-fold lower precipitation compared to multi-year value. This moisture shortage contributed to the extended and non-uniform emergence of plants which resulted in the reduction of their growth and development, and consequent increase in broad bean infestation by phytopathogenic fungi. The reaction of Fabaceae plants on moisture shortage was confirmed in the study conducted by Chmura et al. [4].

According to these authors [4], insufficient precipitation and water amount in soil in the post-drought years do not fully satisfy the processes of Fabaceae plants germination and emergence, their vegetative development and generative organs growth. It also limits the use of nutrients. This leads to abnormal activity of soil microflora.



Source: own work / Źródło: opracowanie własne

Fig. 1. Weather conditions during broad bean growing season according to Meteorological Station in Prusy near Krakow
Rys. 1. Warunki pogodowe w okresie wegetacji bobu wg Stacji Meteorologicznej w Prusach k. Krakowa

Table 1. The mean index of infection (ip%) of overground parts of broad bean by fungal pathogens in years 2010-2012
Tab. 1. Średni indeks porażenia (ip %) części nadziemnej bobu przez patogeny grzybowe w latach 2010-2012

Fungal pathogens (diseases)	Years			LSD $_{0.05}$
	2010	2011	2012	
Fungi diseases on shoots				
Fusarium spp. (broad beans shoots fusarium)	25.74	39.20	66.87	8.25
B. fabae (broad bean chocolate blotch)	25.11	29.87	46.87	3.32
A. fabae (broad bean ascochytosis)	25.91	55.95	71.20	4.89
Fungi diseases on leafs				
B. fabae (broad bean chocolate blotch)	39.29	31.67	63.20	5.56
A. fabae (broad bean ascochytosis)	29.33	36.33	42.40	3.60
Fungi diseases on pods				
B. fabae (broad bean chocolate blotch)	34.03	49.87	38.60	5.26
A. fabae (broad bean ascochytosis)	32.05	34.93	55.80	6.01
U. fabae (rust)	31.76	27.13	39.47	2.94
B. cinerea (gray mold)	35.77	32.80	46.93	5.48

Source: own work / Źródło: opracowanie własne

It was found in this study that the best health status was characteristic for the plants in 2010, which was the most humid and cooler. In relation to 2011, an excessive moisture observed in May 2010 resulted in a significant increase in only chocolate blotch of the leaves (*B. fabae*) and rust on the pods (*U. viciae fabae*). An increase in these diseases presence severity in conditions of excessive moisture was emphasized by Fiedorow et al. [8, 18].

The results of three-year study presented in Table 2 demonstrate that the examined broad bean varietes showed no significant differentiation in the index of various parts of plants infestation by pathogenic fungi such as *A. fabae* (ascochytosis), *B. cinerea* (pods gray mold), *Fusarium* spp. (shoots fusarium). It was found in the study that only the leaves and pods of Windsor White variety were characterized by a significant increase in chocolate blotch (*B. fabae*) and pods rust (*U. fabae*) compared to Hangdown White variety.

Regardless of broad bean variety, the intensity of plant protection with biopreparations differentiated the severity of fungal diseases occurrence during the growing season. The results (Table 3) indicate that the increase in the number of protective treatments of broad bean with these preparations reduced the infection index of stems, leaves and pods mainly by *B. fabae* (chocolate spot). A significant limitation in chocolate blotch development was especially caused by the fifth protection combination (K5), i.e., broad bean seeds treatment with Polyversum WP biopreparation and five times foliar application of biotechnical preparations during the growing period (4 × Bioczos BR + 1 × Biosept 33 SL). In this study, the same combination of protection (K5) also resulted in a significant decrease in the index of shoots infestation by *A. fabae* and *Fusarium* spp., and a tendency to limit ascochytosis development on the leaves and pods. The results obtained are consistent with earlier studies of Boligłowa et al. [1].

Five times foliar application of biopreparations (4 × Bioczos BR and 1 × Biosept 33 SL (K 5) also contributed to the significant decrease in the index of pods infestation by *U. fabae* (rust) and *B. cinerea* (gray mold) in relation only to the control plot (Table 4). A similar relationship was confirmed in earlier studies conducted by Boligłowa et al. [1]. Similar protective effects in other plants were also obtained by Mazur [12, 13] and Dłużniewska et al. [6, 7].
It may be concluded from the three-year study that the use of a smaller number of broad bean protective treatments with Bioczos BR preparation (two and three times) did not cause any significant changes in the analyzed diseases occurrence severity. Therefore, the number of broad bean protective treatments with biological preparations should be increased in conditions favoring fungal infections. Similar opinion was also expressed by Mazur [12, 13]. According to many authors [1, 12, 20, 22] the effectiveness of natural preparations in plants protection against diseases is not unequivocal. According to Mazur and Waksmundzka [11], Boligłowa et al. [1] the reasons of such effects should be seen in the changing weather conditions occurring during the treatments with biopreparations. However, there are still no reports in the range of broad bean biological control against fungal diseases in the literature available.

4. Conclusions

Hydrothermal conditions in the examined growing seasons significantly modify the occurrence and severity of broad bean fungal diseases. Windsor White broad bean variety aimed for an early use, is significantly stronger infested by *B. fabae* (leaves and pods), and pods also by *U. fabae* (rust) compared to Hangdown White variety.

Table 2. The mean index of infection (ip %) of overground parts of broad bean varieties by fungal pathogens (2010-2012)
Tab. 2. Średni indeks porażenia (ip %) części nadziemnej odmian bobu przez patogeny grzybowe (2010-2012)

Fungal diseases	varieties		LSD $_{0.05}$
	Windsor White	Hangdown White	
Fungi diseases on shoots:			
broad beans shoots fusarium (Fusarium spp.)	43.11	44.76	n.s
broad bean chocolate blotch *(B. fabae)*	32.96	34.93	n.s.
broad bean ascochytosis (*A. fabae*)	50.85	51.18	n.s.
Fungi diseases on leafs:			
broad bean chocolate blotch *(B. fabae)*	46.06	43.38	2.57
broad bean ascochytosis (*A. fabae*)	36.39	35.66	n.s.
Fungi diseases on pods:			
broad bean chocolate blotch *(B. fabae)*	42.41	39.26	2.10
broad bean ascochytosis (*A. fabae*)	40.60	41.24	n.s.
rust *(U. fabae*)	34.32	31.25	1.88
gray mold *(B. cinerea)*	39.53	37.46	n.s.

n.s.- not significant difference

Source: own work / Źródło: opracowanie własne

Table 3. An average index (ip%) of broad bean aerial parts infestation by pathogenic fungi (2010–2012)
Tab. 3. Średni indeks porażenia (ip %) części nadziemnych bobu przez grzyby chorobotwórcze (2010-2012)

Biological plant protection combination	*B. fabae* (broad bean chocolate blotch)	*Ascochyta fabae* (broad bean ascochytosis)	*Fusarium* spp. (broad beans shoots fusarium)
Infection index shoots (ip %)			
K1	35.89	53.18	49.26
K2	35.15	51.22	44.33
K3	34.89	51.08	42.98
K4	33.11	49.70	42.07
K5	31.15	49.89	41.04
LSD $_{0.05}$	2.49	1.23	3.45
Infection index leafs (ip %)			
K1	47.07	37.56	not observed
K2	44.33	37.63	
K3	44.48	34.52	
K4	43.85	35.00	
K5	43.89	35.41	
LSD $_{0.05}$	2.32	n.s	-
Infection index pods (in %)			
K1	43.78	44.54	not observed
K2	41.01	43.72	
K3	40.03	37.09	
K4	39.03	39.82	
K5	38.30	39.43	
LSD $_{0.05}$	1.37	n.s.	-

K1 – K5 in methodology; n.s.- not significant difference

Source: own work / Źródło: opracowanie własne

Table 4. An average index (ip %) of broad bean pods infestation by *U. fabae* (rust) and *B. cinerea* (gray mold) depending on biological protection intensity (2010–2012)
Tab. 4. Średni indeks porażenia (ip %) strąków bobu przez U. fabae (rdza) i B. cinerea (szara pleśń) w zależności od intensywności ochrony biologicznej (2010-2012)

Biological plant protection combination	Infection index (ip %) by:	
	U. fabae (rust)	*B. cinerea* (gray mold)
K1	38.10	44.54
K2	35.07	41.28
K3	32.02	35.12
K4	31.88	36.14
K5	27.88	35.41
$LSD_{0.05}$	6.53	8.18

K1 – K5 in methodology
Source: own work / Źródło: opracowanie własne

An increased intensity of broad bean protection with biological preparations limits the severity of fungal diseases occurrence during the growing season. Significant limitation to chocolate blotch development on the leaves, stems and pods, as well as rust and gray mold on pods, is provided by broad bean seeds treatment with Polyversum WP biopreparation and five-time foliar application of natural preparations during the growing season (4 × Bioczos BR + 1 × Biosept 33 SL). Applied biological control has proved to be little effective in broad bean protecting against ascochytosis (*A. fabae*).

5. References

[1] Boligłowa E., Gleń K., Gospodarek J.: Wpływ biologicznej ochrony na zdrowotność bobu odmiany Hangdown Biały. Journal of Research and Applications in Agricultural Engineering, 2012, 57 (3), 15-18.

[2] Buzi A., Chilosi G., Timperio A. M., Zolla L., Rossall S., Magro P.: Polygalacturonase produced by *Botrytis fabae* as elicitor of two furanoacetylenic phytoalexins in *Vicia faba* pods. Journal of Plant Pathology, 2003, 85 (2), 111-116.

[3] Compant S., Duffy B., Nowak J., Clement Ch., Barka A.: Use of plant growth-promoting bacteria for biocontrol of plant diseases: principles, mechanisms of action, and future prospects. Appl. Environ. Microbiol., 2005, 71 (9), 4951-4959.

[4] Chmura K., Chylińska E., Dmowski Z., Nowak L.: Rola czynnika wodnego w kształtowaniu plonu wybranych roślin polowych. Infrastruktura i Ekologia Terenów Wiejskich, PAN, 2009, 9, 33-44.

[5] Deising H., Jungblut R., Mendgen K.: Differentiation-related proteins of the broad bean rust fungus *Uromyces viciae-fabae*, as revealed by high resolution two-dimensional polyaerylamide gel electrophoresis. Archives of Microbiology, 1991, 155, 191-198.

[6] Dłużniewska J.: Przydatność biopreparatów do ochrony wierzby energetycznej (*Salix Viminalis* L.) przed patogenami grzybowymi**.** Prog. Plant Prot/Post. Ochr. Roślin, 2006, 46 (2), 632-635.

[7] Dłużniewska J., Nadolnik M., Kulig B.: Porównanie wpływu ochrony środkami konwencjonalnymi z ochroną środkami w rolnictwie ekologicznym na zdrowotność bobiku (*Vicia Faba* L.). Prog. Plant Prot./Post. Ochr. Roślin, 2008, 48 (2), 706-709.

[8] Fiedorow Z., Gołębniak B., Weber Z.: Choroby roślin rolniczych. AR. Poznań, 2004, 157-160.

[9] Hang J., Wu M., Li G-Q., Yang L., Yu L., Jiang D-H., Huang H-C., Zhuang W-Y.: *Botrytis fabiopsis*, a new species causing chocolate spot of broad bean in central China. Mycologia,2010, 102(5): 1114–1126. DOI: 10.3852/09-217.

[10] Martyniuk S.: Czynniki wpływające na wykorzystanie biopestycydów mikrobiologicznych w ochronie roślin. Prog. Plant Protect./Post. Ochr. Roślin, 2012, 52 (4), 957-962.

[11] Mazur S., Waksmundzka A.: Effect of some compounds on the decay of strawberry fruitscaused by *Botrytis cinerea* Pers. Med. Fac. Landbouww. Univ. Gent, 2001, 66/2a, 227-231.

[12] Mazur S., Nawrocki J.: Wykorzystanie związków naturalnych w ochronie marchwi przed alternariozą. Rocz. AR Pozn., 2007, CCCLXXXIII, Ogrodn.41, 565-569.

[13] Mazur S.: Wpływ ochrony truskawki środkami naturalnymi na porażenie owoców i liści przez niektóre grzyby patogeniczne. Prog. Plant Protect./Post. Ochr. Roślin, 2009, 49 (1), 378-382.

[14] Mnichowska H., Pędziński M.: Bób. Owoce Warzywa Kwiaty, 2002, 6, 28.

[15] Olszewska M.: Reakcja koniczyny białej uprawianej na dwóch typach gleb na stres wodny. Acta Sci. Pol. Agricultura, 2004, 3 (2), 203.

[16] Podleśny J.: Wpływ ilości i rozkładu opadów w okresie wegetacji na wzrost, rozwój i plonowanie samokończących i tradycyjnych odmian bobiku. Acta Agroph., 2009, 14 (20), 413-416.

[17] Rashid K.Y., Bernier C.C., Conner R.L.: Evaluation of faba bean for resistance to *Ascochyta fabae* and development of host differentials for race identification. Plant Diseases, 1991, 75, 852-855.

[18] Sahar E.A., El-Shennawy R.Z., Ismail A.I.: Fungicidal management of chocolate spot of faba bean and assessment of yield losses due to the disease. Annals of Agricultural Science, 2011, 56, 27-35.

[19] Sosnowska D., Fiedler Ż. : Biologiczna ochrona upraw pod osłonami jako przykład udanego wykorzystania metody biologicznej. Prog. Plant Protect./Post. Ochr. Roślin, 2010, 50 (3), 1080-1088.

[20] Stompor-Chrzan E.: Wpływ wybranych biopreparatów na rozwój *Colletotrichum lindemuthianum* Brioso et cav. na fasoli w warunkach polowych i laboratoryjnych. Prog. Plant Protect./Post. Ochr. Roślin, 2007, 47 (4), 216-219.

[21] Tomalak M., Sosnowska D., Lipa J.J.: Tendencje rozwoju metod biologicznych w ochronie roślin. Prog. Plant Prot./Post. Ochr. Roślin, 2010, 50 (4), 1650–1660.

[22] Tomalak M., Zaremba M.: Dostępność środków ochrony roślin w rolnictwie ekologicznym. Prog. Plant Prot./Post. Ochr. Roślin, 2004, 4 (1), 462-472.

[23] Tyburski J., Żakowska-Biemans S.: Wprowadzenie do rolnictwa ekologicznego. SGGW, Warszawa, 2007, 130-190.

[24] Voegele R.T., Struck C., Hahn M., Mendge K.: The role of haustoria in sugar supply during infection of broad bean by the rust fungus *Uromyces fabae*. Plant Biology. PNAS, 2001, 98(14), 8133-8138.

[25] Walsh U.F., Morrissey J.P., O'Gara F.O.: Pseudomonas for biocontrol of phytopathogens: from functional genomics to commercial exploitation. Environ. Biotechnol., 2001, 12, 289-295.

[26] Wenzel H.: Zur Erfassung des Schadenausmasses in Pflanzenschutzversuchen. Pflanzenschutzberichte, 1948, 15, 81-84.

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