Acta Agroph., 2018, 25(1), 59-71
doi: 10.31545/aagr0005

YIELD-PROTECTIVE EFFICIENCY OF BIOLOGICAL AND CHEMICAL POTATO PROTECTION AGAINST *PHYTOPHTORA INFESTANS* (MONT.) DE BARY

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Abstract. Potato protection against blight is an indispensable element of cultivation technology in all production systems. Having in mind food safety and environmental protection, the goal is to limit the chemical protection of plants in favour of other methods, including biological ones. Therefore, the study aimed to evaluate an effect of chemical (Ridomil Gold MZ 68 WP and Infinito 687.5 SC, Flowbrix 380 SC), biological (Polyversum WP, Timorex Gold 24 EC, Biosept Active 33 SL) and integrated protection (alternate biopreparations and Flowbrix 380 SC) on tuber yield of early (Vineta) and moderately early (Red Fantasy) potato cultivars. The field experiment was carried out in the years 2012-2014 near Cracow, Poland (50º07'N, 20º05'E and altitude 271 m a.s.l.) in soil conditions of Luvic Chernozem, developed from loess. Potato protection against blight contributed to a significant increase in yield in all variants of protection, except Polyversum WP. Ridomil Gold MZ 68 WP and Infinito 687.5 SC fungicides were the most effective; their application resulted in 35% higher tuber yields compared to the control plants. Flowbrix 380 SC application caused a 22% yield increase, while plant extracts used individually and alternately with Flowbrix 380 SC fungicide resulted in 16-17% increase.

Keywords: potato, late blight, protection, tuber yield, yield structure

INTRODUCTION

The cause of the most serious and economically important fungal disease of potato is the fungus-like organism *Phytophtora infestans*. The widespread prevalence of this pest, constant changes and the creation of physiological breeds, as well as the rapid and easy spread, make it very difficult to protect potato against the blight (Andrivon 1996, Hermansen *et al.* 2000). Earlier prevalence and more severe course of the disease as well as higher aggressiveness of the pest are increasingly observed (Sawicka and Kapsa 2001, Wiik 2014). The development of the blight is closely related to the meteorological conditions prevailing during the intensive development of potato plants (Abd-El-Khair and Wafaa 2007, Kapsa 2007). Under conditions conducive to the development of *P. infestans*, even intensive chemical treatments do not protect the plants completely from potential yield losses (Cwalina-Ambroziak *et al.* 2015). Effective protection against the strong infective pressure of the virulent and aggressive *P. infestans* is provided by an integrated protection method using cultivars highly resistant to the blight (Kapsa 2008, Michalska *et al.* 2011, Aav 2016). The high resistance of potato to the late blight causes that in years unfavourable for the development of this pathogen it is possible to limit the number of chemical treatments and even to eliminate them (Chmielarz *et al.* 2014). Potato protection programs should be based on models of blight occurrence prediction, resistance of cultivars, and environmentally friendly practices (Andreua and Caldiz 2006, Noaema *et al.* 2017). In the ecological system of production, the possibility of potato blight development limitation is mainly caused by agrotechnical treatments, cultivation of resistant cultivars and application of copper preparations (Bangemann *et al.* 2014). The gradual withdrawal of fungicides containing copper compounds due to the strong toxicity of this element has become a stimulus for the search for alternative ways to reduce fungal diseases development. It can be concluded from earlier studies that satisfactory results in potato protection are obtained in the case of use of *P. infestans* antagonists (Stephan *et al.* 2005, Cwalina-Amroziak 2012). High effectiveness in potato blight limitation is noted for, inter alia, *Bacillus subtilis*, *Chaetomium globusom*, *Saccharomyces cerevisiae*, *Pythium* sp., *Trichoderma* sp., *Pseudomonas* sp., *Penicilium* sp. (Jindal *et al.* 1988, Gupta *et al.* 2004, Benhamou *et al.* 2012, El-Mougy *et al.* 2012, Shanthiyaa *et al.* 2013). Also plant extracts are environmentally friendly and effective in *P. infestans* development control (Stephan *et al.* 2005, Wang *et al.* 2007, Abayhne and Chauhan 2016).

The yield-protective function of fungicides and insecticides is primarily related to the maintenance of possibly the largest assimilation surface of the plants to the end of their vegetation. According to the studies by Kołodziejczyk (2012) and Kołodziejczyk and Szmigiel (2012), the reduction of the assimilation surface of potato plants leads to significant crop reduction as well as modification of tubers chemical composition.

The aim of the study was to determine the effect of biopreparations and synthetic fungicides used in the protection of potato against blight on tuber yield and its structure.

MATERIAL AND METHODS

The study was carried out in the years 2012-2014 at the Experimental Station of the University of Agriculture in Krakow (50°07'N and 20°05'E). A two-factor field experiment was established in a randomised block design, in 4 replicates. The experimental factors were the cultivar and the method of potato protection against blight. The evaluation included an early cultivar Vineta (resistance to potato blight 2 on 1-9 scale) and moderately early Red Fantasy (resistance to potato blight 3 on scale 1-9). A detailed description of plant protection variants against *P. infestans* is presented in Table 1. The first treatment was performed after the symptoms of disease were observed on the underground part of the plant, i.e., in the 2nd-3rd decade of June. Ridomil Gold MZ 68 WP and Infinito 687.5 SC fungicides were applied at 2-week intervals, while the other preparations were administered weekly. Tubers dressing with Polyversum WP was done immediately before planting.

Table 1. Late blight management

	Treatment	Application	
		dose or concentration	active substance
1	Control – no protection	–	–
2	Ridomil Gold MZ 68 WP and Infinito 687.5 SC	2 kg ha^{-1} and 1.6 dm^3 ha^{-1}	metalaxyl-M + mancozeb (38.8 + 640 g kg^{-1}) and propamocarb-hydrochloride + fluopicolide (625 + 62.5 g dm^{-3})
3	Flowbrix 380 SC	4 x 1.6 dm^3 ha^{-1}	copper (380 g dm^{-3})
4	Polyversum WP	dressing tubers 10 g kg^{-1} and 4 x spraying plants 0,05%	oysters *Pythium oligandrum* (10^6 g^{-1})
5	Polyversum WP and Flowbrix 380 SC	dressing tubers 10 g kg^{-1} and 4 x 1.6 dm^3 ha^{-1}	oysters *Pythium oligandrum* (10^6 g^{-1}) and copper (380 g dm^{-3})
6	Timorex Gold 24 EC	4 x 1.5 dm^3 ha^{-1}	tea tree oil (23.8%)
7	Biosept Active 33 SL	4 x 1.5 dm^3 ha^{-1}	grapefruit extract (33%)
8	Flowbrix 380 SC / Timorex Gold 24 EC	alternately 2 x 1.6 dm^3 ha^{-1} / 2 x 1.5 dm^3 ha^{-1}	copper (380 g dm^{-3}) / tea tree oil (23.8%)
9	Flowbrix 380 SC / Biosept Active 33 SL	alternately 2 x 1.6 dm^3 ha^{-1} / 2 x 1.5 dm^3 ha^{-1}	copper (380 g dm^{-3}) / grapefruit extract (33%)
10	Timorex Gold 24 EC / Biosept Active 33 SL	alternately 2 x 1.5 dm^3 ha^{-1} / 2 x 1.5 dm^3 ha^{-1}	tea tree oil (23.8%) / grapefruit extract (33%)

The forecrop for potato was winter wheat. Following the wheat harvest, crushed straw was ploughed and a catch crop (white mustard) was sown. In spring, mineral fertilisers were applied in the following doses: 150 kg N, 60 kg P_2O and 180 kg K_2O ha^{-1}. Potato tubers were planted at 75 x 35 cm spacing in the second week of April. The harvesting plot area was 18 m^2. Weed infestation was limited by mechanical and chemical methods using linuron and quizalofop-p-ethyl (Linurex 500 SC, 1000 g a.i. ha^{-1} and Targa Super 05 EC, 75 g a.i. ha^{-1}). Thiametoxsam (Actara 25 WG, 20 g a.i. ha^{-1}) was used against the Colorado potato beetle. Potato harvest was made in the 3rd decade of September.

The field experiment was located on a Luvic Chernozem developed from loess. The arable soil layer (0-30 cm) revealed a high abundance in P (75.7-81.7 mg kg^{-1}) and Mg (103.1-127.4 mg kg^{-1}); medium K abundance (129.2-158.3 mg kg^{-1}); slightly acid reaction (pH$_{KCl}$ 5.8-6.1); sand content of 112-120 g kg^{-1}; silt 523-550 g kg^{-1}; clay 327-338 g kg^{-1}; organic C concentration of 11.3-11.6 g kg^{-1} and total N at 1.23-1.27 g kg^{-1}.

The characteristics of the precipitation-thermal conditions during potato vegetation are presented in Table 2. Potato vegetation season in 2012 was characterised by the smallest amount of precipitation in the three-year cycle of the study. May and August were classified as very dry and June was very wet. The amount of precipitation in 2013 was close to the long-term average, but its distribution was uneven. June was extremely wet, May and September wet, and July and August were very dry. In turn, potato vegetation in 2014 was run under excessive precipitation, especially in July and August, which was conducive to the development of *P. infestans*.

Table 2. Meteorological conditions during potato vegetation in the years 2012-2014

Year	Month						Mean/Sum
	IV	V	VI	VII	VIII	IX	
	Sielianinov`s hydrothermal coefficient*						
2012	2.2	0.5	2.8	1.1	0.4	0.8	1.2
2013	0.7	2.2	4.1	0.4	0.4	2.4	1.7
2014	1.7	2.7	1.7	2.9	2.6	2.1	2.4
	Rainfalls (mm)						
2012	65	23 (–37)	143 (+70)	69 (+9)	24	35	358
2013	20	99 (+43)	213 (+139)	27 (–30)	26	86	471
2014	43	108 (+58)	80 (+14)	183 (+122)	142	98	654
Long-term period 1981-2010	48	79	89	85	77	65	443

* < 0.4 extremely dry, 0.4-0.7 very dry, 0.8-1.0 dry, 1.1-1.3 fairly dry, 1.4-1.6 optimum, 1.7-2.0 fairly wet, 2.1-2.5 wet, 2.6-3.0 very wet, > 3.0 extremely wet; (+) excess and (–) deficit of rainfall compared to the water needs of potato acc. to Klatt (citation after Nyc, 2006)

Before harvesting, tuber samples from 10 randomly selected potato plants (about 10 kg) were collected from each plot. The number of tubers from a plant, average tuber weight, commercial tubers fractions (over 35 mm in diameter) and large tubers (over 50 mm in diameter) were determined. The overall yield of tubers was determined during the harvest.

The results were subjected to statistical evaluation using an analysis of variance. Highly significant differences (*HSD*) for the investigated features were verified using Tukey`s test at a significance level of $\alpha < 0.05$.

RESULTS AND DISCUSSION

The study demonstrated a significant effect of cultivar characteristics, manner of potato protection against *P. infestans* as well as weather conditions and interactions of these factors on the size and composition of general yield of tubers (Tab. 3). Protection of potato against blight contributed to a significant yield increase in all variants of protection, except for the treatment in which Polyversum WP was applied in the form of tuber dressing and foliar application (Tab. 4). The low yield-protective efficiency of *Pythium oligandrum* in potato cultivation was also reported by Kurzawińska and Mazur (2009). However, the authors showed significantly lower infestation of leaves and tubers by *P. infestans* compared to the control plot after this preparation application. The highest yield-protective efficiency was noted in the case of fungicides of deep and systemic activity (Ridomil Gold MZ 68 WP and Infinito 687.5 SC); 35% higher tuber yields were noted after their application compared to the control plot. Lower yields were recorded on the plots protected with fungicides with contact activity. The application of Flowbrix 380 SC preparation resulted in a 22% yield increase, while plant extracts used individually and alternately with Flowbrix 380 SC fungicide caused an increase at a level of 16-17%. The combination of Polyversum WP and Flowbrix 380 SC gave a better effect than the individual treatment of *P. oligandrum* but worse than the use of the Flowbrix 380 SC fungicide alone. Al-Mughrabi (2008) demonstrated a similar relationship investigating the effect of *Trichoderma atroviride* and Bravo 500 F on the severity of *P. infestans*.

Table 3. Significance of differences of individual sources of variation

Variance source	Tuber yield	Number of tubers per plant	Average weight of tuber	Share of tubers:	
				marketable	large
Protection (A)	***	***	***		***
Cultivar (B)	***	***	***		***
Year (C)	***	***	***	***	***
AxB		***	***		**
AxC	***	***	**		*
BxC	***	***	***		***
AxBxC	***	***	***		*

Significant effect at α < 0.05 (*), α < 0.01 (**) and α < 0.001 (***). Blank values indicate no significant effect (α > 0.05)

Potato plants protected by Polyversum WP and a combination of Polyversum WP and Flowbrix 380 SC, as well as Ridomil Gold MZ 68 WP and Infinito 687.5 SC, produced significantly more tubers than unprotected plants. The obtained results are consistent with those reported by Pytlarz-Kozicka *et al.* (2015) who showed a beneficial effect of seed dressing on the number of shoots and stolons, and consequently on the number of tubers. The protection of potato against *P. infestans* did not differentiate the share of commercial tuber fractions in the overall yield, however, it determined the share of large tubers and average tuber weight. A higher share of large tubers, as well as an increase of average tuber weight compared to the control plot were noted in each of the assessed variants, except for the plants protected with Polyversum WP and the combination of Polyversum WP and Flowbrix 380 SC. The efficacy of potato protection against blight probably affected the length of plants vegetation and thus the duration of tubers development and their weight.

Table 4. Tuber yield and its structure depending on protection method, cultivar and year of study

Factor		Tuber yield ($t\ ha^{-1}$)	Number of tubers per plant (pcs)	Average weight of tuber (g)	Share of tubers: marketable (%)	Share of tubers: large (%)
Variant of protection						
Control		36.4 d	10.7 bc	103 d	89 a	65 d
Ridomil Gold 72 WP and Infinito 687.5 SC		49.0 a	11.5 a	127 a	92 a	75 ab
Flowbrix 380 SC		44.3 b	11.2 ab	118 b	92 a	74 abc
Polyversum WP		37.0 d	11.5 a	104 d	91 a	71 bc
Polyversum WP and Flowbrix 380 SC		42.0 c	11.6 a	107 cd	92 a	71 bc
Timorex Gold 24 EC		42.8 bc	11.0 ab	115 bc	93 a	76 a
Biosept Active 33 SL		43.6 bc	11.4 ab	112 bc	92 a	72 abc
Flowbrix 380 SC / Timorex Gold 24 EC		43.3 bc	11.2 ab	111 bc	92 a	74 abc
Flowbrix 380 SC / Biosept Active 33 SL		43.1 bc	11.4 ab	111 bc	91 a	71 bc
Timorex Gold 24 EC / Biosept Active 33 SL		42.7 bc	10.2 c	113 bc	91 a	70 c
Cultivar						
Vineta		43.2 a	10.7 b	117 a	92 a	74 a
Red Fantasy		41.6 b	11.6 a	107 b	91 a	70 b
Year						
2012		37.1 c	7.6 c	137 a	93 a	83 a
2013		44.1 b	13.3 a	95 c	89 b	56 c
2014		46.1 a	12.7 b	104 b	92 a	78 b
$LSD_{0.05}$ for:	variant of protection	1,9	0,7	7	n.s.	4
	cultivar	0,9	0,2	1	n.s.	1
	year	0,9	0,4	3	2	2

Different letters indicate significant differences between means ($\alpha < 0.05$)

The cultivars examined in the study differed in yield, number of bulbs from a plant, average tuber weight and the share of large tubers in the yield (Tab. 4). Also a differentiated reaction of these cultivars to humidity and thermal conditions during the study period was demonstrated. Cwalina-Amroziak (2012) showed that weather conditions and cultivar have a greater impact on potato yield than protection against blight. This is confirmed by the results of our research. The weather conditions in 2013, and in particular the large amount of precipitation in June that year, were more conducive to better yield of the early potato cultivar than the moderately early potato (Tab. 5). In turn, longer vegetation season of the Red Fantasy cultivar with the luxurious water supply in 2014 allowed the production of significantly higher number of tubers. The early cultivar of potato, Vineta, developed tubers with a higher average weight and was characterised by a higher share of large tubers in the yield. Moreover, a different reaction of the cultivars to the way of protection against *P. infestans* was noted in the range of yield components development. In the case of Red Fantasy, there was no significant effect of protection on the number of tubers (Fig. 1A), and beneficial effects of each of the evaluated variants of protection on the average tuber weight, as well as on the share of large tubers in the yield (Figs. 1B, 1C). Protective effect on the formation of the tuber yield structure of the early cultivar (Vineta) was not clear. An increase in the number of tubers per plant was noted in 6 combinations of protection, it was reduced in 1 variant, and in 2 variants there was no reaction (Fig. 1A). A significant effect of protection on the average tuber weight in this cultivar was only found after the use of Ridomil Gold MZ 68 WP and Infinito 687.5 SC, and Flowbrix 380 SC fungicides (Fig. 1B).

Table 5. Tuber yield and its structure depending on cultivar and year of study

Year	Tuber yield ($t\ ha^{-1}$)		Number of tubers per plant (pcs)		Average weight of tuber (g)		Share of large tubers (%)	
	Vineta	Red Fantasy	Vineta	Red Fantasy	Vineta	Red Fantasy	Vineta	Red Fantasy
2012	36.3 b	37.9 c	7.3 c	7.8 b	140 a	134 a	86 a	80 a
2013	47.3 a	40.9 b	13.2 a	13.3 a	101 c	90 c	56 c	56 c
2014	46.1 a	46.0 a	11.7 b	13.8 a	111 b	98 b	81 b	75 b
$LSD_{0.05}$	1,6		0,5		4		3	

Different letters indicate significant differences between means ($\alpha < 0.05$)

Studies show that the protection program should be adapted to both meteorological conditions and to the level of resistance of the cultivar to be cultivated. The obtained results find confirmation in the research by Kapsa (2008) and Noaema *et al.* (2017). The cultivation of potato cultivars resistant to late blight is one of the most important non-chemical methods of reducing the harmfulness of this disease. The major aim of potato breeding programs for resistance to *P. infestans* is the development of horizontal resistance (Tian *et al.* 2006). Non-specific (horizontal) resistance is the polygenic resistance, controlled by a large number of minor genes. It is characterised by a relatively lower level of resistance, more environment dependent and it is not overcome by emerging of new pathogen races (Sedláková *et al.* 2011).

The highest yields of potato tubers in the three-year study period were obtained in 2014, a year which was characterized by precipitation higher than the long-term average and than the demand of potatoes in the whole vegetation period (Tab. 4). In turn, the lowest yields, mainly due to the small number of tubers, were recorded in 2012, in which precipitation amount was the lowest in the study period, with particular rainfall deficiency in May. In turn, small amounts of precipitation in July and August 2013 reduced tuber development, resulting in only 56% share of large tubers in the general yield. In the opinion of Kołodziejczyk (2013), weather conditions play a dominant role in the phenotypic variability of tuber yield and its components. In cultivar studies, the author showed over 76% share of agro-meteorological factors in tuber yield variability, and 55 and 39% contribution of this source of variability in the number of tubers per plant and average tuber weight, respectively. On the other hand, in the studies of Sawicka and Pszczółkowski (2017), the genotype x environment interaction played a dominant role in shaping the size and structure of potato tuber yield.

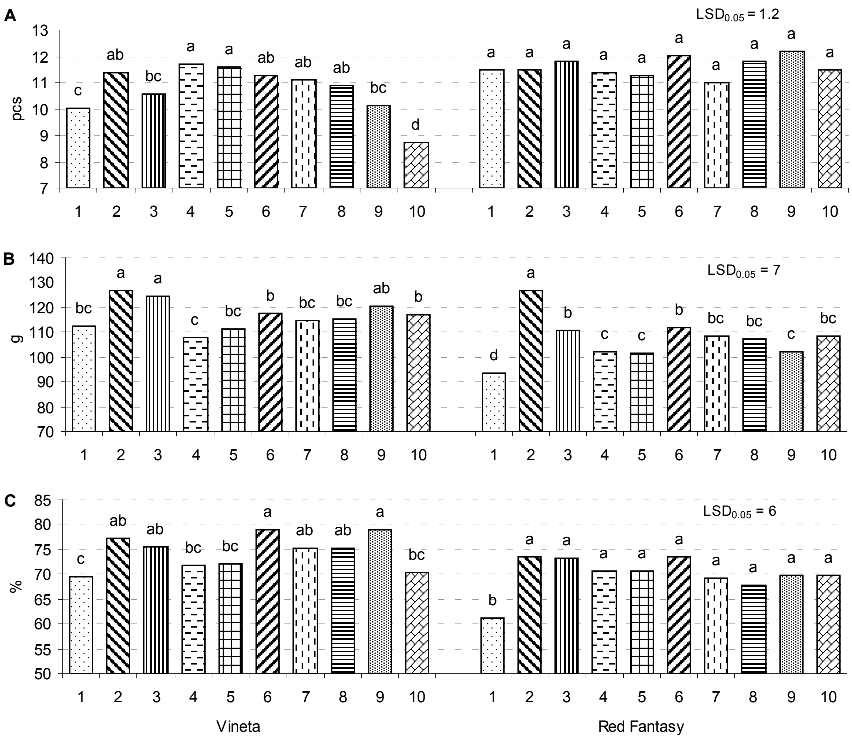

Fig. 1. Number of tubers per plant (A), average weight of tuber (B), share of large tubers (C) in the aspect of interaction between cultivar and protection method: 1 – control; 2 – Ridomil Gold 72 WP and Infinito 687.5 SC; 3 – Flowbrix 380 SC; 4 – Polyversum WP; 5 – Polyversum WP and Flowbrix 380 SC; 6 – Timorex Gold 24 EC; 7 – Biosept Active 33 SL; 8 – Flowbrix 380 SC/Timorex Gold 24 EC; 9 – Flowbrix 380 SC/Biosept Active 33 SL; 10 – Timorex Gold 24 EC/Biosept Active 33 SL. Different letters indicate significant differences between means ($\alpha < 0.05$).

The study demonstrated an interaction of weather conditions and protection practices on potato yield (Fig. 2A). The application of chemical fungicides provided a significant increase in tuber yield regardless of weather conditions. In turn, the yield-protective efficiency of biofungicides used in the form of plant extracts was higher in the years with lower precipitation (2012 and 2013) than in excessively wet conditions (2014). Moreover, a beneficial effect of all variants of protection on the number of tubers produced in 2013, and reduced value of this feature in 2014 after the alternating use of Timorex Gold 24 EC and Biosept Active 33 SL fungicides were noted (Fig. 2B).

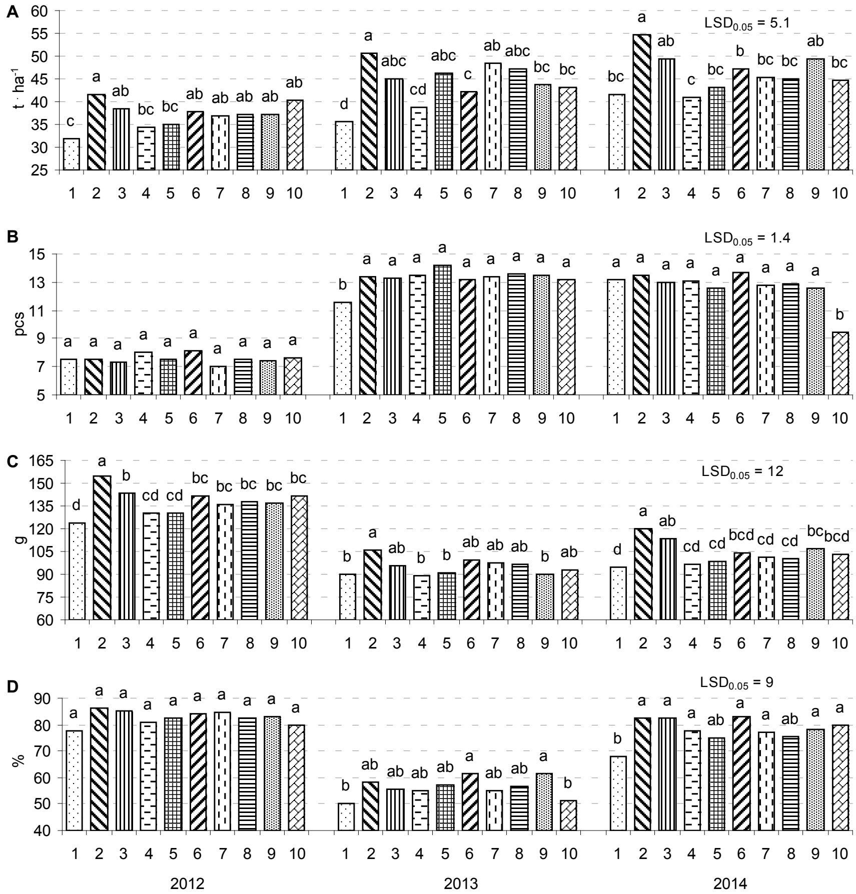

Fig. 2. Tuber yield (A), number of tubers per plant (B), average weight of tuber (C), share of large tubers (D) in the aspect of interaction between year and protection method: 1 – control; 2 – Ridomil Gold 72 WP and Infinito 687.5 SC; 3 – Flowbrix 380 SC; 4 – Polyversum WP; 5 – Polyversum WP and Flowbrix 380 SC; 6 – Timorex Gold 24 EC; 7 – Biosept Active 33 SL; 8 – Flowbrix 380 SC/Timorex Gold 24 EC; 9 – Flowbrix 380 SC/Biosept Active 33 SL; 10 – Timorex Gold 24 EC/Biosept Active 33 SL. Different letters indicate significant differences between means ($\alpha < 0.05$)

The small amount of precipitation in 2012 contributed to an increase in potato protection efficiency, which resulted in a significant increase in average tuber weight in most evaluated variants of protection (Fig. 2C). Analysing the weather conditions in 2012, which were more conducive to the development of the perpetrator of alternariosis than of potato blight, it can be assumed that the tested fungicides, including biopreparations, may also limit the development of *Alternaria* fungi. The results obtained are confirmed in the studies by Singh (2008).

Potato protection against *P. infestans* plays a special role especially in conditions conducive to the development of this pathogen (Ahmed *et al.* 2015). This is also demonstrated in the results of the study which showed a significant increase in the share of large tubers in the total yield in most of the examined variants in 2014, characterised by an excessive amount of precipitation (Fig. 2D). Kurzawińska and Mazur (2012) consider that biopreparations, despite their lower efficacy than that of chemical fungicides, can be used prophylactically in protecting potatoes against *P. infestans*. In addition, the use of these preparations makes it possible to reduce the consumption of chemical protection agents, improves the quality of tubers, and is environmentally-friendly.

CONCLUSIONS

The results, obtained in three seasons with different weather conditions, show good yield-protective efficiency of plant extracts used individually and alternately with copper preparations. The positive influence of these potato protection options against *P. infestans* was also observed in the case of the average tuber weight and the share of large tubers in the yield. Better effects of biological and integrated protection were achieved in years with less rainfall. The interactions between the cultivar and the method of protection, confirmed in the research, indicate that the choice of a suitable variant of protection should take into account features of potato cultivars, such as e.g. the duration of vegetation and blight resistance. Although the variants of biological protection evaluated in these studies had worse yield-protective efficiency than chemical protection, they can be recommended for use in organic and integrated potato production, provided they are approved for use on the area of a particular country. To extend the application of the obtained results, the research should be continued under different habitat conditions.

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PLONOCHRONNA EFEKTYWNOŚĆ BIOLOGICZNEJ I CHEMICZNEJ OCHRONY ZIEMNIAKA PRZED *PHYTOPHTORA INFESTANS* (MONT.) DE BARY

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Streszczenie. Ochrona ziemniaka przed zarazą jest niezbędnym elementem agrotechniki we wszystkich systemach produkcji. W trosce o zachowanie bezpieczeństwa żywności i ochronę środowiska dąży się do ograniczenia chemicznej ochrony roślin na korzyść innych metod, w tym metody biologicznej. Dlatego przeprowadzono badania, w których oceniano wpływ ochrony chemicznej (Ridomil Gold MZ 68 WP i Infinito 687,5 SC, Flowbrix 380 SC), biologicznej (Polyversum WP, Timorex Gold 24 EC, Biosept Active 33 SL) oraz integrowanej (przemiennie biopreparaty i Flowbrix 380 SC) na plonowanie ziemniaka wczesnego (Vineta) i średnio wczesnego (Red Fantasy). Badania polowe realizowano w latach 2012-2014 koło Krakowa, Polska (50º07'N, 20º05'E i wysokości 271 m n.p.m.) w warunkach glebowych czarnoziemu zdegradowanego wytworzonego z lessu. Ochrona ziemniaka przed zarazą przyczyniła się do istotnej zwyżki plonu we wszystkich wariantach ochrony z wyjątkiem Polyversum WP. Największą efektywnością plonochronną odznaczały się fungicydy Ridomil Gold MZ 68 WP i Infinito 687,5 SC, po zastosowaniu których stwierdzono o 35% większe plony bulw niż w obiekcie kontrolnym. Aplikacja preparatu Flowbrix 380 SC zapewniła 22% przyrost plonu, natomiast ekstraktów roślinnych stosowanych indywidualnie oraz przemiennie z fungicydem Flowbrix 380 SC na poziomie 16-17%.

Słowa kluczowe: ziemniak, zaraza ziemniaka, ochrona, plon bulw, struktura plonu