ACTA SCIENTIARUM POLONORUM
Acta Sci. Pol. Agricultura 17(1) 2018, 13–22
www.agricultura.acta.utp.edu.pl pISSN 1644-0625 eISSN 2300-8504 DOI: 10.37660/aspagr.2018.17.1.2

ORIGINAL PAPER

Received: 10.02.2018
Received in revised form: 26.03.2018
Accepted: 20.04.2018

OCCURRENCE OF DEFECTS OF POTATO TUBERS IN CONDITIONS OF APPLICATION OF HERBICIDES AND BIOSTIMULANTS

Marek Gugała[1]✉, Krystyna Zarzecka[1], Anna Sikorska[2], Honorata Dołęga[3]

[1]Department of Agrotechnology, Siedlce University of Natural Sciences and Humanities
B. Prusa 14, 08-110 Siedlce, **Poland**
[2]Department of Agriculture, State Higher Vocational School in Ciechanów
Narutowicza 9, 06-400 Ciechanów, **Poland**
[3] Enterprise Multi-branch „Soleks" Wojnów, **Poland**

ABSTRACT

Background. The aim of this study was to estimate the effect of herbicides and biostimulants on the occurrence of external and internal defects in the yield of semi-early cultivars of table potato.

Material and methods. The field experiment was established as two-factorial in the split-plot design, in three replications. The experiment included: I factor – three semi-early cultivars of table potato: Bartek, Gawin, Honorata; II factor – five methods of application of herbicides and biostimulants: 1) the control: only mechanical weed control, 2) herbicide Harrier 295 ZC in a dose of 2.0 $dm^3 \cdot ha^{-1}$, 3) herbicide Harrier 295 ZC in a dose of 2.0 $dm^3 \cdot ha^{-1}$ and then, after the plant emergence, the bioregulator Kelpak SL twice, in a dose of 2.0 $dm^3 \cdot ha^{-1}$, 4) herbicide Sencor 70 WG in a dose of 1.0 $kg \cdot ha^{-1}$, 5) herbicide Sencor 70 WG, an then, after the plant emergence, the biostimulant Asahi SL twice, in a dose of 1.0 $dm^3 \cdot ha^{-1}$. To identify external defects, 100 tubers were collected from each plot and replicate at the time of harvesting. In the commercial fraction, external defects including: shape defects, greening, mechanical damage as well as those caused by pests and couch grass, were determined by weight. Then, to determine internal defects, samples were collected from three replicates for each cultivar and each method of application of herbicides and biostimulants. Internal defects, i.e. internal heart necrosis and brown hollow heart, were determined on 30 tubers of size above 0.035 m, on the longitudinal cross-section.

Results. Analysis of variance showed that both the yield of tubers of the commercial fraction and the yield of tubers <0.035 m were significantly affected by the humidity and thermal conditions during the study, the cultivar and the ways of application of herbicides and biostimulants. Moreover, a significant effect of the years of the study, cultivars and ways of application of herbicides and biostimulators on the percent share of tubers with external and internal defects and the weight of tubers with defects was demonstrated.

Conclusion. The highest yield of tubers of commercial and small fractions were obtained in 2012. Most external defects were found in 2014, in addition, the sum of external and internal defects was the highest in this season and amounted to 12.2%. The smallest number of tubers with external and internal defects was found in the Honorata cultivar, 1.4% and 0.2%, respectively. Also, the sum of defects and the weight of tubers with defects was the smallest in the Honorata cultivar and was, respectively, 1.6% by weight and 0.60 $Mg \cdot ha^{-1}$. The herbicides and biostimulants used in the study influenced the percent share of tubers with defects in yield. The smallest number of external and internal defects was found after the application of the herbicide Sencor WG and the biostimulant Asahi SL.

Key words: external defects, growth regulators, internal defects, potato, yield of the commercial fraction

✉ gugala@uph.edu.pl, krystyna.zarzecka@uph.edu.pl, anna.sikorska@pwszciechanow.edu.pl, honoratadolega@gmail.com

© Copyright by Wydawnictwa Uczelniane Uniwersytetu Technologiczno-Przyrodniczego w Bydgoszczy

BY-NC

INTRODUCTION

In Poland, potatoes are a popular vegetable with a high consumption of about 100 kg per person per year. However, there is a constant downward trend in the consumption of potatoes – intended for direct consumption as vegetables, while the consumption of potato products increases. Changes in the potato market lead to the concentration and professionalization of table potatoes production (Nowacki, 2016). The primary objective of cultivation is to obtain the maximum yield of commercial tubers. However, the weight percentage of by-product yield in the total domestic yield of potatoes is substantial: it is an average of 30%, which consists of small tubers with a diameter ≤ 0.035 m and tubers with external and internal defects. Defects of tubers are caused by improper harvesting, damage caused by pests, diseases and weeds occurring in potato crops or may result from individual physiological predisposition intensified under the pressure of climatic factors (Nowacki, 2006). Therefore, potato growers very often use industrial means of production (mineral fertilizers, herbicides, insecticides or fungicides). However, in modern agriculture, more and more often it is aimed at reducing their use, and preparations stimulating the growth and development of plants and improving the quality of harvested crops are increasingly implemented. These preparations are called biostimulants, which include: growth regulators, immune stimulants, soil conditioners or growth promoters (Filipczak *et al*., 2016; Koziara *et al*., 2006; Maciejewski *et al*., 2007).

The study assumes a research hypothesis that weed control treatments using herbicides can limit the occurrence of external and internal defects of potato tubers. However, there are no studies on the effect of herbicides in combination with biostimulants on tuber health and the occurrence of defects. Therefore, the aim of this study was to determine the impact of herbicides and biostimulants on the occurrence of external and internal defects in the yield of table potato tubers.

MATERIAL AND METHODS

The field study was carried out in Wojnów (52°12′ N; 22°34′ E) in 2012–2014. The experiment was established using a randomized split-plot design in three replications. The experiment tested as follows:
I factor: three semi-early cultivars of table potato: Bartek, Gawin, Honorata,
II factor: five methods of use of herbicides and biostimulants:

1. The control: mechanical weed control before and after potato plant emergence, i.e. before emergence, double hilling and single hilling with harrowing (at intervals of 7–10 days), and after emergence, double hilling without harrowing (to interrow coverage).
2. Mechanical and chemical weed control, i.e. single hilling (7 days after planting), then about 7–10 days after planting the tubers, spraying with the herbicide Harrier 295 ZC was performed in a dose of 2.0 $dm^3 \cdot ha^{-1}$,
3. Mechanical and chemical weed control, i.e. single hilling (7 days after planting), then about 7–10 days after planting the tubers, the herbicide Harrier 295 ZC was applied in a dose of 2.0 $dm^3 \cdot ha^{-1}$, then at the end of emergence of potato plants, the biostimulant Kelpak SL was used in a dose of 2.0 $dm^3 \cdot ha^{-1}$, and again the biostimulant Kelpak SL was used in a dose of 2.0 $dm^3 \cdot ha^{-1}$ at interrow coverage in 10-50% (14-28 days after the first application),
4. Mechanical and chemical weed control, i.e. before emergence, double hilling and single hilling with harrowing (at intervals of 7-10 days), and just before emergence, the herbicide Sencor 70 WG was applied in a dose of 1.0 $kg \cdot ha^{-1}$,
5. Mechanical and chemical weed control, i.e. before emergence, double hilling and single hilling with harrowing (at intervals of 7–10 days), and just before emergence, the herbicide Sencor 70 WG was applied in a dose of 1.0 $kg \cdot ha^{-1}$, then at the end of potato plant emergence, the biostimulant Asahi SL in a dose of 1.0 $dm^3 \cdot ha^{-1}$, and again the biostimulant Asahi SL was applied in a dose of 1.0 $dm^3 \cdot ha^{-1}$ at interrow coverage in 10-50 % (14–28 days after the first application).

The field experiment was conducted in soils of the type Luvisols belonging to the agronomic category I, the order brown earths, quality class IV b, classified to the very good rye complex in terms of agricultural suitability. In the individual years of the study, the soils differed in the content of organic matter and available macroelements. The content of organic matter ranged from 15.0 to 18.7 g·kg^{-1}, the content of available phosphorus ranged from high to very high, the potassium content from medium to very high, and the magnesium content was high. The content of P and K was determined with the Egner-Riehm method. Phosphorus was determined with the colorimetric method, potassium was determined with atomic emission spectrometry (AES) and magnesium was determined using atomic absorption spectrophotometry (AAS) (Houba *et al*., 1995). The pH of the soil was determined using a digital pH meter in a deionized water suspension and 1 mole KCL in a ratio of 5:1. In subsequent years of the study, the pH was: 5.60 in 2012 and 2013 and 7.30 in 2014.

The previous crop in subsequent years of the study was winter wheat. After harvesting the previous crop, post-harvest cultivation was made. In autumn, every year preceding planting the tubers, natural fertilization was used in the form of manure in an amount of 25.0 Mg·ha^{-1} and mineral phosphorus-potassium fertilization in the amount of P – 44.0 kg·ha^{-1} and K – 124.5 kg·ha^{-1} The fertilizer applied was Lubofos for potatoes. The fertilizers were ploughed in with autumn ploughing. Nitrogen fertilizers were sown in the spring before planting potatoes at a rate of 100 kg·ha^{-1} of nitrogen in the form of nitro-chalk.

The weight of tubers with a diameter above 0.035 m was assumed to be the yield of tubers of the commercial fraction. The weight of tubers up to 0.035 m in diameter was assumed to be small tubers. To determine external defects, 100 tubers were collected from each plot and replication at the time of harvesting. In the commercial fraction, the percent share of tubers with external defects including: shape defects, greening, mechanical damage as well as those caused by pests and couch grass, were determined by weight. Then, to determine internal defects, samples were collected from three replicates for each cultivar and each method of application of herbicides and biostimulants. Internal defects, i.e. internal heart necrosis and brown hollow heart, were determined on 30 tubers of size above 0.035 m, on the longitudinal cross-section (Roztropowicz *et al*., 1999; MRiRW, 2003).

The results of the study were statistically analysed using the analysis of variance, and the means were compared using Tukey's test at $P < 0.05$.

The weather conditions prevailing in individual growing seasons were varied (Table 1). In the growing season of 2013, determined as optimal, the highest total rainfall was recorded (441.3 mm), the mean air temperature was 15.0ºC and the Sielianinow's coefficient 1.60. The lowest total rainfall (264.9 mm) was recorded in 2012, with the mean air temperature at 15.4^{o}C. Based on the value of the Sielianinow's hydrothermal coefficient (K = 0.95), the 2012 growing season was defined as dry. The year 2014, in turn, was characterized by the total rainfall of 335.1 mm, and the air temperature was 15.3^{o}C. In terms of humidity, the discussed year according to the Sielianinow's coefficient (K = 1.20) was described as quite dry (Skowera, 2014).

RESULTS AND DISCUSSION

The conducted experiment showed a significant effect of weather conditions (years), cultivars and methods of using herbicides and biostimulants on the yield of the commercial fraction of potatoes (Table 2). The highest mean yield of the commercial fraction was obtained in 2012, which was characterized by a favorable distribution of temperatures and rainfalls during potato growth. According to Kołodziejczyk *et al*. (2007), Sekutowski and Badowski (2010) and Zarzecka *et al*. (2013), the climatic and soil conditions have a very large impact on the size and quality of tuber yield.

Of the potato cultivars grown in the experiment, Honorata gave the highest yield, while the yields of Gawin was significantly lower. Also Pytlarz-Kozicka and Zagórski (2013) noted varietal differences in the yield size of the commercial fraction. Higher yields were obtained from the crop of the Polish cultivar Bartek – 42.6 Mg·ha^{-1}, while the yields of the Dutch cultivars Annabelle and Innovator were significantly lower, 16.4 and 27.3 Mg·ha^{-1}, respectively.

Table 1. Weather conditions in potato growing period in the years 2012–2014

Year	Month						
	April	May	June	July	August	September	April-September
	Rainfalls, mm						Sum
2012	29.9	53.4	76.2	43.0	51.0	11.4	264.9
2013	36.0	105.9	98.8	91.3	15.0	94.3	441.3
2014	45.0	92.7	55.4	10.0	105.7	26.3	335.1
Multiyear total (1987–2000)	38.6	44.1	52.4	49.8	43.0	47.3	275.2
	Air temperature, ^{o}C						Mean
2012	8.9	14.6	16.3	20.7	18.0	14.1	15.4
2013	7.4	15.3	18.0	19.0	18.8	11.7	15.0
2014	9.8	13.5	15.4	20.8	18.1	14.1	15.3
Multiyear mean (1987–2000)	7.8	12.5	17.2	19.2	18.5	13.1	14.7
	Sielianinow's hydrothermic coefficients*						Mean
2012	1.10	1.20	1.60	0.69	0.94	0.27	0.95
2013	1.60	2.30	1.80	1.60	0.30	2.70	1.60
2014	1.50	2.30	1.20	0.16	1.90	0.62	1.20

*value of Sielianinov's coefficient (Skowera, 2014)
≤ 0.40 – extremely dry, 0.4 < K ≤ 0.7 – very dry, 0.70 < K ≤ 1.0 – dry, 1.0 < K ≤ 1.3 – quite dry, 1.3 < K ≤ 1.6 – optimum, 1.6 < K ≤ 2.0 – moderately moist, 2.0 < K ≤ 2.5 – humid, 2.5 < K ≤ 3.0 – very humid, K > 3.0 – extremely humid

Table 2. Yield of commercial fraction of tubers > 0.035 mm, Mg·ha^{-1}

Weed control methods	Cultivar			Year			Mean
	Bartek	Gawin	Honorata	2012	2013	2014	
1. Control	30.85	29.16	28.89	31.23	29.02	28.65	29.63
2. Harrier 295 ZC 2.0 dm^3·ha^{-1}	34.77	33.30	37.52	37.72	35.54	32.33	35.20
3. Harrier 295 ZC 2.0 dm^3·ha^{-1}; 2 × Kelpak SL 2.0 dm^3·ha^{-1}	38.90	37.57	40.03	47.00	35.29	34.21	38.83
4. Sencor 70 WG 1.0 kg·ha^{-1}	40.14	37.54	43.37	43.50	36.92	40.62	40.35
5. Sencor 70 WG 1.0 kg·ha^{-1}; 2 × Asahi SL 1.0 dm^3·ha^{-1}	43.30	41.51	45.86	49.30	39.17	42.19	43.55
Mean	37.59	35.82	39.13	41.75	35.19	35.60	–

$HSD_{0.05}$ for:
years 2.13 cultivars 2.13 weed control methods 1.94
interaction:
cultivars × weed control methods ns years × weed control methods 3.36

ns – non-significant differences

Analysing the impact of methods of using herbicides and biostimulants, it was found that the largest weight of commercial tuber fraction was collected for the treatment using the herbicide Sencor 70 WG and the biostimulator Asahi SL. The smallest yield was obtained for the control. Mystkowska *et al*. (2017), using various weed control methods – mechanical and mechanical-chemical with the application of herbicides and their mixtures, proved that they had a significant effect on potato yields. Kalinowski and Wadas (2017), in turn, after the application of the biostimulator Tytanit obtained a total yield of tubers higher by 2.26 $Mg \cdot ha^{-1}$ (7.5%), and a commercial yield higher by 1.88 $Mg \cdot ha^{-1}$ (6.4%) as compared with the control. Trawczyński and Prokop (2016) obtained a higher commercial yield (from 11.1 to 14.5%) compared with the control treatment after the application of the fertilizer Eurofertil 33N-Process supplemented with the foliar fertilizers Fertileader Gold and Fertileader Axis.

Also, there was a significant correlation between the years and methods of using herbicides and biostimulants, which confirms the varied effect of the preparations used in the studied seasons on the yield size of the potato tuber commercial fraction.

Analysis of variance showed a significant effect of experimental factors on the percent share of small tuber weight (Table 3). The percent share of such tubers was determined by the weather conditions in individual years of the study. The smallest mass of small tubers occurred in 2014, while the largest in 2013. The influence of humid and thermal conditions on a large number of small potato tubers was reported in earlier studies by Gugała *et al*. (2010) and Trawczyński (2014).

Of the cultivars grown, the cultivar Honorata was characterized by the largest number of small tubers. Also Krzysztofik (2012) showed that the percent share of tubers with a diameter < 0.035 m was significantly varied in cultivars. Zarzyńska (2011) stated that in organic production Polish cultivars were characterized by a higher yield of the commercial fraction compared with western cultivars. However, she did not find any significant differences regarding the commercial quality of tubers, i.e. the percent share of external and internal defects of tubers depending on the origin of the cultivars.

Table 3. Yield of small potato tubers with a diameter < 0.035 mm, $Mg \cdot ha^{-1}$

Weed control methods	Cultivar			Year			Mean
	Bartek	Gawin	Honorata	2012	2013	2014	
1. Control	3.25	3.52	5.68	8.73	1.97	1.75	4.15
2. Harrier 295 ZC 2.0 $dm^3 \cdot ha^{-1}$	3.12	3.19	3.21	5.97	2.16	1.40	3.17
3. Harrier 295 ZC 2.0 $dm^3 \cdot ha^{-1}$; 2 × Kelpak SL 2.0 $dm^3 \cdot ha^{-1}$	1.98	2.21	2.51	3.74	1.78	1.19	2.24
4. Sencor 70 WG 1.0 $kg \cdot ha^{-1}$	2.65	3.50	2.76	6.87	1.25	0.80	2.97
5. Sencor 70 WG 1.0 $kg \cdot ha^{-1}$; 2 × Asahi SL 1.0 $dm^3 \cdot ha^{-1}$	1.41	1.30	1.58	5.37	0.98	0.94	1.43
Mean	2.48	2.74	3.13	5.54	1.63	1.22	–

$HSD_{0.05}$ for:
years 0.56 cultivars 0.56 weed control methods 1.01
interaction:
cultivars × weed control methods 1.45 years × weed control methods 1.26

The largest percent share of small tubers was recorded on the control object, while the smallest in the facility where Harrier 295 ZC herbicide and Kelpak SL biostimulator (2.29 $Mg \cdot ha^{-1}$) were used, as well as in which the herbicide Sencor 70 WG + biostimulant Asahi SL (1.43 Mg·ha^{-1}) were applied. These results were confirmed by earlier studies by Gugała *et al*. (2014) and in the study by Kowalska (2016) who obtained the largest percent share of tubers with a size of at least 0.055 m on treatments where EM Farma Plus and UGmax were used, while the smallest on control plots.

In the present study, there was a significant interaction between the years and the methods of using herbicides and biostimulants, as well as between the cultivars and weed control and stimulation methods in shaping the yield size of small tubers.

Statistical calculations showed a significant effect of the years of the study, the cultivars and the methods of using herbicides and biostimulants on the percent share of tubers with external and internal defects and their sum and weight of tubers with defects (Table 4–7). The weather conditions prevailing in individual years of the study significantly affected the percent share of external defects, while they did not have a significant effect on the occurrence of internal defects. The most external defects (tuber shape deformations, greening, damage caused by mechanical factors as well as by pests and couch grass) were found in 2014, which in individual growing months was alternately humid and dry. Also, the sum of external and internal defects was the largest in that season and amounted to 12.2%. The most internal defects were found in conditions of low humidity in 2012, however, the differences were not significant compared with the other years of the study. The studies by Jakubowski (2012) and by Zarzyńska and Goliszewski (2012) indicate that the years of the study are the factor that diversifies the percent share of tubers with defects in the yield to the greatest extent. According to Trawczyński and Prokop (2016), weather conditions can affect the yield size and the quality of tubers, significantly differentiating the percent share of large and deformed tubers in the yield.

Analysis of variance showed a significant effect of the cultivars on the value of the traits under discussion (Tables 4–7). The smallest number of tubers with external and internal defects was found in the cultivar Honorata, 1.4% and 0.2%, respectively. Also, the sum of defects and the weight of tubers with defects were the smallest in the cultivar Honorata and amounted to 1.6% and 0.60 Mg·ha^{-1}, respectively. In contrast, the largest number of tubers with both external and internal defects were found in the cultivar Bartek. The effect of the cultivar on the occurrence of defects is evidenced by studies by Zarzyńska and Wroniak (2007), Jakubowski (2012), Krzysztofik (2012) and Zarzecka *et al*. (2014).

Table 4. Share of potato tubers with external defects, % by weight

Weed control methods	Cultivar			Year			Mean
	Bartek	Gawin	Honorata	2012	2013	2014	
1. Control	18.70	9.50	3.80	6.70	8.10	17.20	10.70
2. Harrier 295 ZC 2.0 dm^3·ha^{-1}	12.07	4.70	0.40	2.90	4.50	9.80	5.70
3. Harrier 295 ZC 2.0 dm^3·ha^{-1}; 2 × Kelpak SL 2.0 dm^3·ha^{-1}	10.60	4.90	0.40	3.20	3.60	9.10	5.00
4. Sencor 70 WG 1.0 kg·ha^{-1}	9.50	4.10	1.30	1.90	3.50	9.50	5.00
5. Sencor 70 WG 1.0 kg·ha^{-1}; 2 × Asahi SL 1.0 dm^3·ha^{-1}	10.27	3.00	1.20	2.50	3.20	8.80	4.80
Mean	12.20	5.20	1.40	3.40	4.60	10.90	–

$HSD_{0.05}$ for:
years 1.1 cultivars 1.1 weed control methods 2.0
interaction:
cultivars × weed control methods ns years × weed control methods ns

ns – non-significant differences

The herbicides and biostimulants used in the study affected the percent share of tubers with both external and internal defects. The largest number of tubers with these defects was recorded in the yield obtained from the control plots, while on the other treatments their percent share was significantly smaller. The smallest number of external and internal defects occurred after the application of the herbicide Sencor WG and the biostimulant Asahi SL, which was confirmed by the study by Trawczyński (2014) who stated that the number of tubers with external defects was smaller, on average by 0.9%, on treatments where a biostimulating fertilizer was applied. Zarzyńska and Goliszewski (2012) showed that the percent share of certain defects depended on the system of production.

Table 5. Share of potato tubers with internal defects, % by weight

Weed control methods	Cultivar			Year			Mean
	Bartek	Gawin	Honorata	2012	2013	2014	
1. Control	5.50	2.30	0.60	3.20	2.40	2.70	2.80
2. Harrier 295 ZC 2.0 $dm^3 \cdot ha^{-1}$	3.10	0.60	0.20	1.90	0.20	1.90	1.30
3. Harrier 295 ZC 2.0 $dm^3 \cdot ha^{-1}$; 2 × Kelpak SL 2.0 $dm^3 \cdot ha^{-1}$	3.30	0.90	0.00	1.40	1.40	1.40	1.40
4. Sencor 70 WG 1.0 $kg \cdot ha^{-1}$	1.20	0.50	0.00	1.00	0.70	0.00	0.60
5. Sencor 70 WG 1.0 $kg \cdot ha^{-1}$; 2 × Asahi SL 1.0 $dm^3 \cdot ha^{-1}$	0.70	0.00	0.00	0.00	0.20	0.50	0.20
Mean	2.80	0.90	0.20	1.50	1.0	1.30	–

$HSD_{0.05}$ for:
years ns cultivars 1.5 weed control methods 2.4
interaction:
cultivars × weed control methods ns years × weed control methods ns

ns – non-significant differences

Table 6. Share of potato tubers with external and internal defects, % by weight

Weed control methods	Cultivar			Year			Mean
	Bartek	Gawin	Honorata	2012	2013	2014	
1. Control	24.10	11.90	4.40	10.00	10.40	20.00	13.50
2. Harrier 295 ZC 2.0 $dm^3 \cdot ha^{-1}$	15.20	5.40	0.60	4.80	4.70	11.70	7.10
3. Harrier 295 ZC 2.0 $dm^3 \cdot ha^{-1}$; 2 × Kelpak SL 2.0 $dm^3 \cdot ha^{-1}$	14.00	5.70	0.40	4.60	5.00	10.50	6.70
4. Sencor 70 WG 1.0 $kg \cdot ha^{-1}$	10.70	4.70	1.30	3.00	4.20	9.50	5.60
5. Sencor 70 WG 1.0 $kg \cdot ha^{-1}$; 2 × Asahi SL 1.0 $dm^3 \cdot ha^{-1}$	11.00	3.00	1.30	2.50	3.40	9.30	5.10
Mean	15.00	6.10	1.60	5.00	5.60	12.20	–

$HSD_{0.05}$ for:
years 2.1 cultivars 2.1 weed control methods 3.2
interaction:
cultivars × weed control methods ns years × weed control methods ns

ns – non-significant differences

Table 7. Weight of potato tubers with internal and external defects, Mg·ha^{-1}

Weed control methods	Cultivar			Year			Mean
	Bartek	Gawin	Honorata	2012	2013	2014	
1. Control	7.29	3.45	1.39	3.55	3.00	5.57	4.04
2. Harrier 295 ZC 2.0 dm^3·ha^{-1}	5.02	1.74	0.24	1.82	1.61	3.58	2.33
3. Harrier 295 ZC 2.0 dm^3·ha^{-1}; 2 × Kelpak SL 2.0 dm^3·ha^{-1}	4.97	2.15	0.16	2.32	1.71	3.25	2.43
4. Sencor 70 WG 1.0 kg·ha^{-1}	4.01	1.77	0.61	1.33	1.51	3.54	2.13
5. Sencor 70 WG 1.0 kg·ha^{-1}; 2 × Asahi SL 1.0 dm^3·ha^{-1}	4.39	1.28	0.59	1.28	1.28	3.69	2.08
Mean	5.13	2.08	0.60	2.06	1.82	3.93	–

$HSD_{0.05}$ for:
years 0.96 cultivars 0.96 weed control methods 1.18
interaction:
cultivars × weed control methods ns years × weed control methods ns

ns – non-significant differences

CONCLUSIONS

1. The herbicides and biostimulants used in potato cultivation had a significant positive effect on the yield of the commercial fraction and significantly limited the occurrence of external and internal defects as compared with the mechanical weed control. The best effects in reducing the occurrence of tubers with external and internal defects were obtained using the herbicide Sencor 70WG and the biostimulant Asahi SL.
2. The yield of the commercial fraction of potato tubers, the percent share and the weight of tubers with external and internal defects are genetically determined. The cultivar Honorata showed favourable values of these traits.
3. The weather conditions during growth had a significant effect both on the yield of the commercial fraction of tubers and on the occurrence of internal and internal defects of tubers.

ACKNOWLEDGEMENTS

The results of the research carried out under the research theme No. 363/S/13 were financed from the science grant granted by the Ministry of Science and Higher Education.

REFERENCES

Filipczak, J., Żurawicz, E., Sas Paszt, L. (2016). Wpływ wybranych biostymulatorów na wzrost i plonowanie roślin truskawki “Elkat”. Zesz. Nauk. Inst. Ogrod., 24, 43–58.

Gugała, M., Zarzecka, K., Mystkowska, I. (2010). Występowanie wad bulw ziemniaka w warunkach stosowania insektycydów nowej generacji. Biul. IHAR 257/258, 103–109.

Gugała, M., Zarzecka, K., Sikorska, A. (2014). Zachwaszczenie i plonowanie ziemniaka w zależności od zabiegów mechaniczno-chemicznych. Fragm. Agron., 31(3), 50–57.

Houba, V.J.G., Van der Lee, J.J., Novozamsky, I. (1995). Soil and plant analysis. Part 5B. Soil analysis procedure other procedure. Wageningen Agric. Univ.

Jakubowski, T. (2012). Assesment of potato tuber parenchyma of seed-potatoes irradiated with microwaves. Agric. Engin., 4(2), 25–33.

Kalinowski, K., Wadas, W. (2017). Effect of Tytanit® on the yield and yield components of very early--maturing potato cultivars. J. Central Europ. Agricul. 18(2), 441–459.

Kołodziejczyk, M., Szmigiel, A., Kiełbasa, S. (2007). Plonowanie oraz skład chemiczny bulw ziemniaka uprawianego w warunkach zróżnicowanego nawożenia. Fragm. Agron., 2(94), 142–150.

Kowalska, J. (2016). Wpływ nawożenia oraz biostymulatorów mikrobiologicznych na zdrowotność i plonowanie ziemniaka w systemie ekologicznym. Prog. Plant Prot., 56 (2), 230–235.

Koziara, W., Sulewska, H., Panasiewicz, K. (2006). Effect of resistance stimulator application to some agricultural crops. J. Res. Appl. Agric. Eng., 51(2), 82–87.

Krzysztofik, B. (2012). Parametry jakościowe ziemniaka oferowanego do przetwórstwa spożywczego. Biul. IHAR, 266, 225–233.

Maciejewski, T., Szukała, J., Jarosz, A. (2007). Influence of biostymulator Asahi SL and Atonik SL on qualitative tubers of potatoes. J. Res. Appl. Agric. Eng., 52(3), 109–112.

MRiRW 2003. Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi w sprawie szczegółowych wymagań w zakresie jakości handlowej ziemniaków. Dz.U. nr 194, poz. 1900.

Mystkowska, I., Zarzecka, K., Baranowska, A., Gugała, M. (2017). Zachwaszczenie łanu i plonowanie ziemniaka w zależności od sposobu pielęgnacji i warunków pogodowych. Acta Agroph., 24(1), 111–121.

Nowacki, W. (2006). Straty plonu handlowego ziemniaków powodowane przez choroby i szkodniki w 2005 roku. Prog. Plant Prot., 46 (1), 193–201.

Nowacki, W. (2016). Rynek ziemniaków jadalnych w Polsce – stan obecny i perspektywy rozwoju. Rocz. Nauk. SERiA, 18(1), 198–201.

Pytlarz-Kozicka, M., Zagórski, P. (2013). The influence of biological potato tuber treatments on health conditions of potato plants and potato yield. Prog. Plant Prot./Post. Ochr. Roślin, 53(2), 333–339.

Roztropowicz, S., Czerko, Z., Głuska, A., Goliszewski, W., Gruczek, T. i in. (1999). Metodyka obserwacji, pomiarów i pobierania prób w agrotechnicznych doświadczeniach z ziemniakiem. IHAR Radzików, Oddział Jadwisin, 1–50.

Sekutowski, T., Badowski, M. (2010). Wpływ zachwaszczenia, warunków meteorologicznych i ochrony herbicydowej na plon i poszczególne frakcje bulw ziemniaka. Prog. Plant Prot./Post. Ochr. Roślin, 50(3), 1390–1394.

Skowera, B. (2014). Zmiany warunków hydrotermicznych na obszarze Polski (1971–2010). Fragm. Agron., 31(2), 74–87.

Trawczyński, C. (2014). Wpływ biostymulatorów aminokwasowych – Tecamin – na plon i jakość ziemniaków. Ziemn. Polski, 3, 29–34.

Trawczyński, C., Prokop, W. (2016). Plon i jakość bulw ziemniaka w zależności od zastosowanego nawożenia z wykorzystaniem doglebowych i dolistnych wieloskładnikowych preparatów nawozowych. Pol. J. Agronomy, 24, 23–29.

Zarzecka, K., Gugała, M., Dołęga, H. (2013). Regulacja stopnia zachwaszczenia ziemniaka z zastosowaniem herbicydów. Biul. IHAR, 267, 113–119.

Zarzecka, K., Gugała, M., Dołęga, H., Sikorska, A. (2014). Występowanie wad bulw w plonie ziemniaka po zastosowaniu użyźniacza glebowego UGmax. Ann. UMCS, sect. E, Agricultura, 69(2), 71–79.

Zarzyńska, K. (2011). Comparison of selected polish and foreign potato cultivars under organic production. J. Res. Appl. Agric. Eng., 56(4), 208–211.

Zarzyńska, K., Goliszewski, W. (2012). Zróżnicowanie jakości plonu ziemniaków uprawianych w systemie ekologicznym i integrowanym w zależności od odmiany i warunków glebowo-klimatycznych Część I. Udział wad zewnętrznych i wewnętrznych bulw. Biul. IHAR, 266, 73–79.

Zarzyńska, K., Wroniak, J. (2007). Differences in quality of potato tubers growing in organic system depending on some agronomical factors. J. Res. Appl. Agric. Eng., 52(4), 108–113.

WYSTĘPOWANIE WAD BULW ZIEMNIAKA W WARUNKACH STOSOWANIA HERBICYDÓW I BIOSTYMULATORÓW

Streszczenie

Celem badań było określenie oddziaływania herbicydów i biostymulatorów na występowanie wad zewnętrznych i wewnętrznych w plonie średnio wczesnych odmian ziemniaka jadalnego. Doświadczenie polowe założono jako dwuczynnikowe w układzie (split–plot), w trzech powtórzeniach. W doświadczeniu zastosowano: I czynnik – trzy średnio wczesne odmiany ziemniaka jadalnego: Bartek, Gawin, Honorata; II czynnik – pięć sposobów stosowania herbicydów i biostymulatorów: 1) wariant kontrolny: pielęgnacja mechaniczna, 2) herbicyd Harrier 295 ZC w dawce 2,0 $dm^3 \cdot ha^{-1}$, 3) herbicyd Harrier 295 ZC w dawce 2,0

$dm^3 \cdot ha^{-1}$, a następnie po wschodach roślin dwukrotnie bioregulator Kelpak SL w dawce 2,0 $dm^3 \cdot ha^{-1}$, 4) herbicyd Sencor 70 WG w dawce 1,0 $kg \cdot ha^{-1}$, 5) herbicyd Sencor 70 WG, a następnie po wschodach roślin dwukrotnie biostymulator Asahi SL w dawce 1,0 $dm^3 \cdot ha^{-1}$. Do oznaczenia wad zewnętrznych z każdego poletka i powtórzenia pobrano w czasie zbioru po 100 bulw. W frakcji użytkowej określono wagowo wady zewnętrzne obejmujące: defekty kształtu, zazielenienia, uszkodzenia mechaniczne oraz przez szkodniki i perz. Następnie do oznaczenia wad wewnętrznych pobrano dla każdej odmiany i każdego sposobu stosowania herbicydów i biostymulatorów próby z trzech powtórzeń. Na 30 bulwach wielkości powyżej 0,035 m, na przekroju podłużnym oznaczono wady wewnętrzne, tj. rdzawą plamistość i brunatną pustowatość. Analiza wariancji wykazała, że zarówno na plon bulw frakcji handlowej i plon bulw < 0,035 m istotny wpływ miały warunki wilgotnościowo-termiczne w czasie badań, odmiany oraz sposoby stosowania herbicydów i biostymulatorów. Ponadto wykazano istotny wpływ lat badań, odmian oraz sposobów stosowania herbicydów i biostymulatorów na udział bulw z wadami zewnętrznymi i wewnętrznymi oraz masy bulw z wadami. Największy plon bulw frakcji handlowej i bulw małych uzyskano w 2012 roku. Najwięcej wad zewnętrznych stwierdzono w 2014 roku, ponadto suma wad zewnętrznych i wewnętrznych była największa w tym sezonie i wynosiła 12,2%. Najmniej bulw z wadami zewnętrznymi i wewnętrznymi stwierdzono u odmiany Honorata, odpowiednio 1,4% i 0,2% wagowo. Również udział i masa bulw z wadami była najmniejsza u odmiany Honorata i wynosiła odpowiednio 1,6% wagowo i 0,60 $Mg \cdot ha^{-1}$. Stosowane w badaniach herbicydy i biostymulatory miały wpływ na udział bulw z wadami w plonie. Najmniej wad zewnętrznych i wewnętrznych stwierdzono po zastosowaniu herbicydu Sencor WG i biostymulatora Asahi SL.

Słowa kluczowe: plon frakcji handlowej, regulatory wzrostu, wady wewnętrzne, wady zewnętrzne, ziemniak