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Journal of Plant Protection Research eISSN 1899-007X

ORIGINAL ARTICLE

The impact of the use of biostimulants and herbicide on reducing the occurrence of defects and small tubers in the potato yield

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Vol. 64, No. 3: 298–306, 2024

DOI: 10.24425/jppr.2024.151251

Received: February 19, 2024
Accepted: April 23, 2024
Online publication: August 05, 2024

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Responsible Editor:
Zuzanna Sawińska

Abstract

The aim of this study conducted in 2018–2020 was to determine the effect of biostimulants and herbicide Avatar 293 ZC on the occurrence of external and internal defects and small tubers in the potato yield. The edible cultivars evaluated were Oberon and Malaga and the biostimulants used were: PlonoStart containing prolactic acid bacteria, actinomycetes (N-16.4%, K_2O-0.75%, CaO-0.07%, MgO-0.02%, S-941 mg · kg^{-1}), Aminoplant containing free amino acids-11.57%, organic matter-87.7% (N_{total}-9.48%, $N_{organic}$-9.2%, N-NH4-0.88%, $C_{organic}$-25.0%), and Agro-Sorb Folium including total amino acids-13.11%, free amino acids-10.66% (N-2.2%, B-0.02%, Mn-0.05%, Zn-0.09%) with herbicides (clomazone and metribuzin): objects 3,4 and 5 and a single herbicide (object 2), as well as a control object (1). Before harvesting, tubers were collected from 10 randomly selected plants from each plot. The yield structure was determined in these samples - the weight share of tubers below 35 mm, 36–50, 51–60 and above 60 mm. Tubers with a diameter of less than 35 mm were classified as small, non-commercial tubers. Tubers with a diameter above 35 mm constituted the commercial fraction, in which external and internal defects were determined. The sum of tubers with defects and small tubers constituted side yield. The use of all biostimulants with herbicide significantly reduced: the share of tubers with defects, the share of small tubers in the yield and the total weight of small tubers and tubers with defects compared to the control plant. The best effects in reducing the occurrence of tubers with external and internal defects and small tubers were obtained by using the Agro-Sorb Folium and herbicide. Among the cultivars, Malaga cv. turned out to be more resistant to defects and the production of small tubers than the Oberon cv. In the literature, especially foreign, there are sporadic studies on the effect of biostimulants on the occurrence of defects in potato tubers.

Keywords: external defects, growth regulators, internal defects, side yield, *Solanum tuberosum* L.

Introduction

As plant diseases have a detrimental effect on agricultural productivity, experts are actively seeking novel and more efficacious ways to increase crop yields. Reducing losses is critically important, and early detection of plant diseases can aid in recommending a treatment strategy and substantially prevent the spread of diseases (Golian *et al.* 2023; Suborna *et al.* 2023). Especially organic farming must deal with pests, diseases and weeds while banning the use of synthetic agrochemicals so as to protect biodiversity and human health. For this purpose, it uses a variety of prevention methods and natural tools to preserve crop health and guarantee productivity and returns (Gwladys and Henri 2019). The use of biostimulants in plant breeding is becoming a common practice, as they provide a range of benefits in terms of growth stimulation, protection against stress, and thus influence yield and quality (Van Oosten *et al.* 2017; Franzoni *et al.* 2022; Mystkowska *et al.* 2023). Under adverse environmental and soil conditions, particularly drought, salinity and extreme temperatures, biostimulants are one of the most promising and effective tools for maintaining yield stability (Trawczyński 2020; Katsenios *et al.* 2023). The Regulation of the Ministry of Agriculture and Rural Development includes requirements for commercial quality of potatoes (Regulation 2003) as well as the book entitled Professional Potato Production (Nowacki 2020). Nowacki's publication brings all farmers – potato producers, as well as traders, processors and advisory services and institutions supervising the functioning of the potato sector – closer to the knowledge of contemporary problems in the production and marketing of this valuable crop and shows detailed requirements for the commercial quality of edible potatoes. The high requirements in the edible potato market and for food processing make it important for the farmer to have not only a total yield, but above all a marketable yield. Production efficiency is largely limited by external and internal defects of tubers (Zarzyńska and Goliszewski 2012; Rykaczewska 2015; Osowski 2021) and the share of small tubers in the yield, which together constitute the non-commercial yield, also referred to as the side yield (Gugała *et al.* 2018; Karak *et al.* 2023). Defects of tubers occur as a result of damage caused by pests, diseases and weeds, as well as incorrect treatments applied during growing and harvesting. They may also result from individual physiology and the reaction of the cultivar to increasing adverse climatic factors (Zarzyńska and Goliszewski 2012; Hara-Skrzypiec 2013). These defects are: external defects including deformations, greening, cracking, secondary growth, skin diseases, mechanical damage, internal defects of the flesh such as internal rust spot of the flesh and brown hollow heart and diminutiveness of tubers (Zarzyńska and Goliszewski 2012; Zarzecka *et al.* 2014; Abd El-Rahman *et al.* 2018; Trawczyński 2020). Caradonia *et al.* (2022) reviewed a number of in vitro, growth chamber, greenhouse and field experiments under a variety of environmental conditions with a range of cultivars for the effects of biostimulants on potato plants. These authors showed that the plant biostimulants analyzed had a beneficial effect on both production (yield) and quality parameters. Among the quality features, the main parameters affected by the biostimulants were: plant height, tuber dry weight, tuber fresh weight, tuber size, protein content, vitamin C, starch content, content of polyphenolic compounds, glycoalkaloid content, and chlorophyll content of leaves. On the other hand, there are only a few studies on the effects of biostimulants on the occurrence of external and internal defects or tuber diminutiveness (Głosek-Sobieraj *et al.* 2018; Gugała *et al.* 2018; Trawczyński 2020; Karak *et al.* 2023). Hence, the aim of this study was to evaluate the effects of biostimulants and herbicides on the incidence of external and internal defects and the proportion of small tubers in the total yield, as these values determine the commercial yield for sale.

Materials and Methods

The field experiment was established as a two-factor split-plot system in three replications at the Agricultural Experimental Station in Zawady, near Siedlce, in eastern Poland (52°03‘N; 22°33‘E). The experiment analyzed the effect of two factors:

– factor I - two cultivars of edible potato – Oberon and Malaga (Table 1),

– factor II - five objects with the application of three biostimulants and one herbicide (Table 2).

Each year (2018–2020), winter triticale was a forecrop for potatoes. After the autumn harvest of the forecrop, natural fertilizers were used: manure in the amount of 25.0 t · ha^{-1} and phosphorus-potassium mineral fertilizers in the amount of 44.0 kg P and 124.5 kg K · ha^{-1}. Fertilizers were introduced into the soil during pre-winter plowing. Nitrogen fertilizers were sown once in spring at a dose of 100 kg N × ha^{-1}, mixed with the soil using a cultivator. Seed potatoes were planted in the 2nd half of April in rows every 40 cm, with a spacing between rows of 67.5 cm. The doses and dates of application of three biostimulants and one herbicide are shown in Table 2. During the vegetation period the following four insecticides were used: Actara 25 WG (thiametoxam 0.08 kg · ha^{-1}), Decis Mega 50 EW (deltamethrin 0.15 dm^3 · ha^{-1}), Karate Zeon 050 CS (lambda-cyhalothrin 0.25 dm^3 · ha^{-1}), Proteus 110 OD (thiachloprid and deltamethrin 0.4 dm^3 · ha^{-1})

Table 1. Characteristics of potato cultivars (Nowacki 2021)

Cultivars	Origin of seed tubers	Maturity	Flesh color	Average yield [t · ha^{-1}]	Share defects – deformations [scale 1–5]	Resistance to mechanical damages [scale 1–9]
Oberon	Poland	medium early	light yellow	53.1	3.7	7.0
Malaga	Poland	medium early	light yellow	56.7	1.0	6.0

Table 2. Methodological data

L.p.	Objects	Total doses [dm^3 · ha^{-1}]	Application in BBCH phase 00–08	Application in BBCH phase 13–19	Application in BBCH phase 31–35
1.	Control object – without the use of preparations	–	–	–	
2.	Herbicide Avatar 293 ZC (clomazone + metribuzin)	1.5	1.5	–	–
3.	Biostimulant PlonoStart containing prolactic acid bacteria, actinomycetes (N-16.4%, K_2O-0.75%, CaO-0.07%, MgO-0.02%, S-941 mg · kg^{-1}) with herbicide Avatar 293 ZC (clomazone and metribuzin)	2.0	–	1.0	1.0
4.	Biostimulant Aminoplant containing free amino acids-11.57%, organic matter 87.7% (N_{total}-9.48%, $N_{organic}$-9.2%, N-NH4-0.88%, $C_{organic}$-25.0%) with herbicide Avatar 293 ZC (clomazone and metribuzin)	1.5	–	1.0	0.5
5.	Biostimulant Agro-Sorb Folium containing total amino acids-13.11%, free amino acids-10.66% (N-2.2%, B-0.02%, Mn-0.05%, Zn-0.09%) with herbicide Avatar 293 ZC (clomazone and metribuzin)	4.0	–	2.0	2.0

and two fungicides: Ridomil Gold MZ 68 (metalaxyl-M and mancozeb 2.0 kg · ha^{-1}) and Dithane Neo Tec 75 WG (mancozeb 2.5 kg · ha^{-1}). Before harvesting, tubers were dug from 10 randomly selected plants in each plot of the experiment. In these samples, the yield structure was determined – the proportion of tuber fractions below 35 mm, 36–50, 51–60 and above 60 mm. Tubers with a diameter of below 35 mm constituted small tubers – non-commercial (Regulation 2003). Tubers with a diameter of more than 35 mm were commercial fractions, and in them external and internal defects were determined according to the methodology given by Roztropowicz (1999). When determining external defects, the following were included: greened tubers, deformed tubers, tubers with common scab, tubers damaged by pests and weeds, tubers with mechanical damage, physiological cracks, and among internal defects – internal rust spot of the flesh and brown hollow hearts were determined. The remaining tubers were then harvested from each plot and, after adding the previously sampled tubers, the total yield per hectare was expressed (t × ha^{-1}). Average total potato yields for cultivars are presented in Table 3.

During all years of the study, the highest total yield was recorded after application of the biostimulant Agro-Sorb Folium with the herbicide Avatar 293 ZC. The lowest yields occurred in the control object.

Potato tubers were harvested during the 1st half of September. The results were subjected to statistical evaluation using an analysis of variance. The studied potato traits were verified by using the test *HSD* Tukey test at a significance level of $p \leq 0.05$ (Trętowski and Wójcik 1991).

The prevailing weather conditions during the 3 years of the study are given in Tables 4 and 5.

Table 3. Average total potato yields for cultivars in t · ha^{-1}

L.p.	Objects	2018	2019	2020	Mean
1.	Control object – without the use of preparations	34.36	29.96	29.26	31.19
2.	Herbicide Avatar 293 ZC (clomazone and metribuzin)	36.82	36.86	30.37	34.68
3.	Biostimulant PlonoStart with herbicide Avatar 293 ZC (clomazone and metribuzin)	37.63	40.46	35.28	37.79
4.	Biostimulant Aminoplant with herbicide Avatar 293 ZC (clomazone and metribuzin)	37.15	38.70	32.45	36.10
5.	Biostimulant Agro-Sorb Folium with herbicide Avatar 293 ZC (clomazone and metribuzin)	39.12	42.02	40.90	40.68
$HSD_{0.05}$					
For years					3.16
For objects					3.24

Table 4. Total monthly rainfall in mm (R) and mean monthly temperatures in ^{0}C (T) during the vegetative growth period in the years 2018–2020 for Zawady

Year	IV		V		VI		VII		VIII		IX		IV–IX	
	R	T	R	T	R	T	R	T	R	T	R	T	R	T
2018	34.5	13.1	27.3	17.0	31.5	18.3	67.1	20.4	54.7	20.6	80.6	15.9	295.7	17.6
2019	5.9	9.8	59.8	13.3	35.9	17.9	29.7	18.5	43.9	19.9	17.4	14.2	192.6	15.6
2020	6.0	8.6	63.5	11.7	118.5	19.3	67.7	19.0	17.9	20.2	38.8	15.5	312.4	15.7
1980–2009	49.6	7.9	48.2	11.2	60.7	16.7	45.7	19.3	53.0	18.0	50.7	13.0	307.9	14.4

Table 5. The Selyaninov's hydrothermal coefficient for Zawady (2018–2020)

Year	Month						
	IV	V	VI	VII	VIII	IX	IV–IX
2018	0.88	0.52	0.57	1.06	0.86	1.69	0.93 dry
2019	0.20	1.44	0.67	0.51	0.71	0.41	0.66 very dry
2020	0.23	1.74	2.05	1.15	0.29	0.83	1.05 relatively dry

In 2018, total rainfall from April to September was 295.7 mm, 12.2 mm less than in the multi-year period, and air temperature was 3.2°C higher. Particularly unfavorable weather conditions prevailed in June due to low rainfall (29.2 mm less) and higher than average air temperature (by 1.6°C). The year 2019 was characterized by the lowest amount of rainfall in the 3-year study period (it accounted for 63% of the multi-year average). Rainfall deficiencies occurred from June until the end of potato vegetation. It was a very dry year. In 2020 there were different moisture conditions. Total rainfall from April to September was slightly higher than the multi-year average, and it was a relatively dry year – the most favorable for potato yield.

Results and Discussion

In the production of edible potatoes, a very important parameter is the commercial yield. At the same time, the proportion of tubers with defects in shape and skin, with internal defects and the proportion of small tubers in the total yield should be as low as possible (Zarzyńska and Goliszewski 2012). The results of the field experiment presented in Table 5 show that the sum of defects including external and internal defects depended significantly on the application of biostimulants combined with herbicide Avatar 293 ZC. The highest number of tubers with defects was found in the yield harvested from the control object treated only mechanically (object 1), while significantly less was found in the objects with application of all biostimulants tested in the experiment as well as herbicide Avatar 293 ZC (objects 2–5). In Trawczyński's research (2020) the application of biostimulant Naturamin WSP containing free amino acids-80.0% (N_{total}-12.8%, $N_{organic}$-12.8%) and biostimulant Naturamin Plus containing free amino acids-40.0% (N-7.50%, Fe-1.25%, Mn-40.0%, B-0.12%, Mo-0.058%, Cu-0.12%, Zn-0.25%) was significantly associated with the lowest proportion of deformed tubers in the yield and a greater reduction in all defects than in the other plots.

According to Zarzecka *et al.* (2020) mechanical treatments were less effective than chemical treatments in reducing weed infestation and caused increased tuber deformation and tuber disease infestation. Also, Głosek-Sobieraj *et al.* (2018) noted that the application of growth regulators and biostimulants, including *Ecklonia maxima* algae extract and *Trichoderma asperellum* fungal spores or sodium para-nitrophenolate, sodium ortho-nitrophenolate and sodium 5-nitroguaiacolate, significantly reduced disease severity and had a positive effect on the yield structure. Zarzyńska and Goliszewski (2012) indicated that the proportion of certain defects (common scab, pox, rust spot) depended on the production system. In the studies conducted, the proportion of internal defects was small and did not depend on experienced factors. According to Osowski (2021) Oberon and Malaga cultivars are resistant to internal rust spot of the flesh and brown hollow hearts.

Mass tubers with defects expressed in tons per hectare depended significantly on the cultivar, application of biostimulants and herbicide. The years of the research are shown in Table 6.

A higher weight of tubers with defects was produced by the Oberon variety than by the Malaga cultivar. In the control object, the weight of tubers with defects was significantly higher than in the other objects with herbicide and biostimulants and herbicide. At the same time, it was observed that objects 2–5

Table 6. Share of tubers with external and internal defects in yield (%) and mass tubers with defects (t)

Factors of the field experiment	External defects [%]	Internal defects [%]	Total defects [%]	Mass tubers with defects [t · ha^{-1}]
Cultivar				
1. Oberon	10.54	0.45	10.99	3.97
2. Malaga	9.09	0.50	9.59	2.93
$HSD_{0.05}$	ns	ns	ns	0.40
Objects – application of biostimulants and herbicide				
1. Control object	13.92	1.41	15.33	4.54
2. Herbicide Avatar 293 ZC (clomazone and metribuzin)	10.17	0.11	10.28	3.24
3. Biostimulant PlonoStart with herbicide Avatar 293 ZC (clomazone and metribuzin)	8.17	0.33	8.50	3.03
4. Biostimulant Aminoplant with herbicide Avatar 293 ZC (clomazone and metribuzin)	9.24	0.46	9.70	3.40
5. Biostimulant Agro-Sorb Folium with herbicide Avatar 293 ZC (clomazone and metribuzin)	7.59	0.07	7.66	3.05
$HS_{D0.0}5$	2.84	ns	3.89	0.86
Years of research				
1. 2018	11.18	0.16	11.34	4.15
2. 2019	9.52	0.20	9.72	3.24
3. 2020	8.76	1.06	9.82	2.97
$HSD_{0.05}$	ns	ns	ns	0.62
Mean	9.81	0.48	10.29	3.45

ns – not significant

did not differ significantly – they formed homogeneous groups. In the conducted research, weather conditions influenced the tuber mass with defects. The lowest weight of these tubers was found in 2020, when rainfall-thermal conditions were favorable for potato yield, and there were more defective tubers in the other years, which were dry and very dry. The influence of weather conditions on this feature was also found by other authors (Zarzyńska and Goliszewski 2012; Gugała *et al*. 2018; Trawczyński 2020) and indicated that wetter and near-optimal years had a lower frequency of tubers with defects than dry seasons. Statistical analysis showed an interaction between cultivars and years of research and the mass of tubers with defects (Fig. 1) as well as an interaction of application of biostimulants with herbicide and years of the research on this potato feature (Fig. 2). The highest weight of tubers with defects was produced by the Oberon cultivar in 2018, which was dry, and the lowest in the relatively dry year 2020 (Fig. 1). In contrast, the response of the Malaga cultivar was different. It was characterized by a lower weight of tubers with defects than Oberon in 2018 and 2019. In 2020, differences in the values of this trait were insignificant. Such a response of cultivars suggests that the selection of a cultivar for cultivation under varying weather conditions is very important. The highest weight of tubers with defects (5.42 t · ha^{-1}) was recorded in 2020 in the control, where the total tuber yield was the lowest (Fig. 2, Tab. 3). Application of Avatar 293 ZC herbicide (object 2) and biostimulants with this herbicide (objects 3, 4, 5) reduced the weight of tubers with defects. The best effects on the mentioned objects were found under the moisture and thermal conditions of the year 2020. The above results indicate that biostimulants leveled the weight of tubers with defects under different weather conditions compared to the control object.

The percentage of the weight of small tubers in the total yield and the weight of these tubers per unit area varied according to application methods with biostimulants and herbicide and meteorological conditions during the research years (Table 7).

The highest share of small tubers and their weight was recorded in the control object (respectively, 7.6% and 2.32 t · ha^{-1}). It was significantly lower on the other sites, while it was lowest after the application of the biostimulant Agro-Sorb Folium containing total amino acids-13.11%, free amino acids-10.66% and herbicide Avatar 293 ZC (respectively, 2.9% and 1.18 t · ha^{-1}). Similar results were obtained by Baranowska *et al.* (2019) using biostimulant Green OK-Uniwersal Pro including humic substances and biostimulant Asahi SL with sodium para-nitrophenolate, sodium ortho-nitrophenolate and sodium 5-nitroguaiacolate and their combinations with herbicide Avatar 293 ZC (clomazone and metribuzin), which significantly reduced the

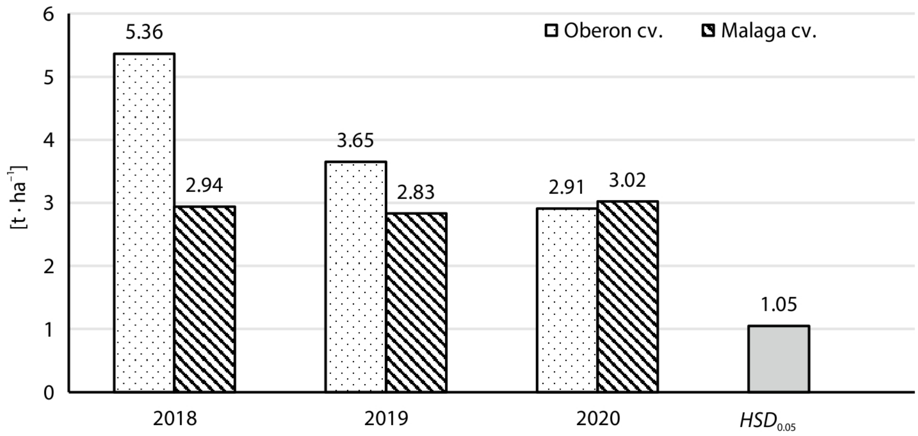

Fig. 1. Effects of cultivar and years of study on the mass of tubers with defects

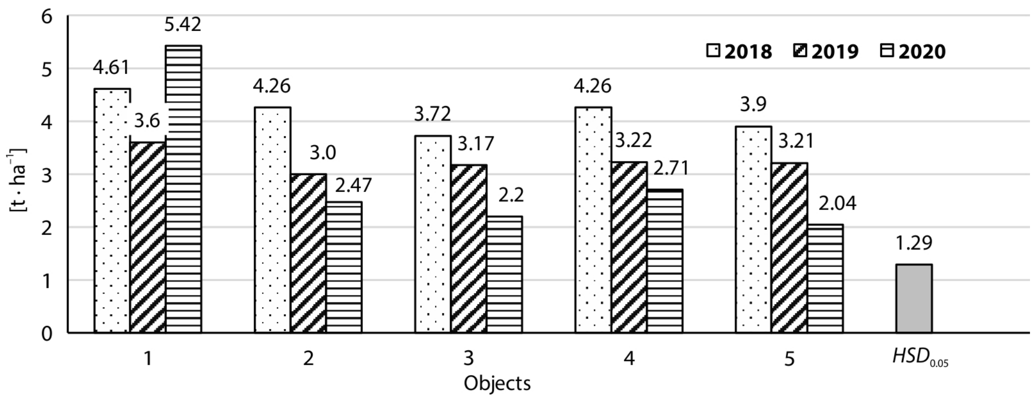

Fig. 2. Effects of application of biostimulants and herbicide and years of study on the mass of tubers with defects

Table 7. Share of small tubers in yield (%) and their mass per 1 ha (t) and mass of small tubers and tubers with defects (t)

Factors of the field experiment	Small tubers [%]	Mass of small tubers per 1 ha [t · ha⁻¹]	Mass of small tubers and tubers with defects [t · ha⁻¹]
Cultivar			
1. Oberon	4.8	1.80	5.77
2. Malaga	4.8	1.59	4.52
$HSD_{0.05}$	n.s.	n.s.	0.65
Objects – application of biostimulants and herbicide			
1. Control object	7.6	2.32	6.86
2. Herbicide Avatar 293 ZC (clomazone and metribuzin)	5.4	1.89	5.13
3. Biostimulant PlonoStart with herbicide Avatar 293 ZC (clomazone and metribuzin)	3.7	1.42	4.45
4. Biostimulant Aminoplant with herbicide Avatar 293 ZC (clomazone and metribuzin)	4.6	1.68	5.08
5. Biostimulant Agro-Sorb Folium with herbicide Avatar 293 ZC (clomazone and metribuzin)	2.9	1.18	4.23
$HS_{D0.0}5$	0.9	0.40	1.50
Years of research			
1. 2018	2.9	1.03	5.18
2. 2019	8.3	3.02	6.26
3. 2020	3.2	1.04	4.01
$HSD_{0.05}$	1.1	0.35	0.96
Mean	4.8	1.70	5.15

share of small tubers less than 35 mm compared to the control object. Also, Gugała *et al.* (2018) by application of herbicide Harrier 295 ZC (clomazone and linuron) and biostimulant Kelpak SL containing *Ecklonia maxima* algae extract found that the weight of the harvested small tubers was twice as low as that of tubers from the control object. At the same time, these authors (2018) reported a threefold higher yield of small tubers (less than 35 mm) in the dry year than in the optimum years. The beneficial effect of the biostimulant on medium and large tuber yield and total yield was also reported by Karak *et al.* (2023). The moisture and thermal conditions in 2019 (very dry) significantly increased the proportion of small tubers and their weight compared to the other years of the research. Research by Głosek-Sobieraj (2018) also showed that the share of tubers less than 35 mm in diameter in Irga and Satina cultivars was highest in the dry year 2015, with 155.4 mm of rainfall, and lowest in the wet year 2013, with 275.2 mm of rainfall.

The weight of small tubers and tubers with defects, together constituting the potato side yield, depended significantly on the cultivar, application of biostimulants and herbicide and years of the research (Table 7).

A higher side yield was produced by the Oberon cultivar than by the Malaga cultivar. A statistically proven effect of cultivar on this trait was also reported by Zarzecka *et al.* (2014). Application of herbicide Avatar 293 ZC and biostimulants significantly reduced the weight of non-commercial tubers compared to the control object. The best effect was obtained after the application of biostimulant Agro-Sorb Folium containing total amino acids-13.11%, free amino acids-10.66% and herbicide Avatar 293 ZC – the side yield was lower by 2.63 t · ha^{-1} than in the object without preparations' protection. Similar effects after application of biostimulants and herbicides were obtained by Gugała *et al.* (2018). The size of the side yield was also determined by weather conditions during potato vegetation. The smallest yield was in 2020 (relatively dry), and the largest in 2019 (very dry). The conducted research also showed an interaction between application of biostimulants and herbicide and years of study (Fig. 3).

The influence of weather conditions on potato yield is indicated by other authors (Gugała *et al.* 2018; Zarzyńska and Goliszewski 2012). Nowacki (2018) concluded that an optimal water supply for potato plants (350–450 mm) improves the commercial quality of tubers (increased tuber shape regularity, reduced deformation and tubers affected by common scab and physiological cracks, lower proportion of small tubers) and stabilizes yields at a high level. Reducing the incidence of defects of tubers is very important from the grower's point of view, as they reduce the commercial yield and are even more important for the consumer – they impair aesthetics and increase losses during mechanical processing. Krzysztofik and Nawara (2007) showed that during mechanical peeling of potatoes, weight losses of shaped tubers were 23.5% and deformed tubers were more than 29%.

Table 8. Mass of small tubers, mass of tubers with defects and their sum (kg · ha^{-1}); a supplement to the manuscript

Factors of the field experiment	Mass of small tubers	Mass tubers with defects	Mass of small tubers and tubers with defects
Cultivar			
1. Oberon	1800	3970	5770
2. Malaga	1590	2930	4520
Objects – application of biostimulants and herbicide			
1. Control object	2320	4540	6860
2. Herbicide Avatar 293 ZC (clomazone and metribuzin)	1890	3240	5130
3. Biostimulant PlonoStart with herbicide Avatar 293 ZC (clomazone and metribuzin)	1420	3030	4450
4. Biostimulant Aminoplant with herbicide Avatar 293 ZC (clomazone and metribuzin)	1680	3400	5080
5. Biostimulant Agro-Sorb Folium with herbicide Avatar 293 ZC (clomazone and metribuzin)	1180	3050	4230
Years of research			
1. 2018	1030	4150	5180
2. 2019	3020	3240	6260
3. 2020	1040	2970	4010

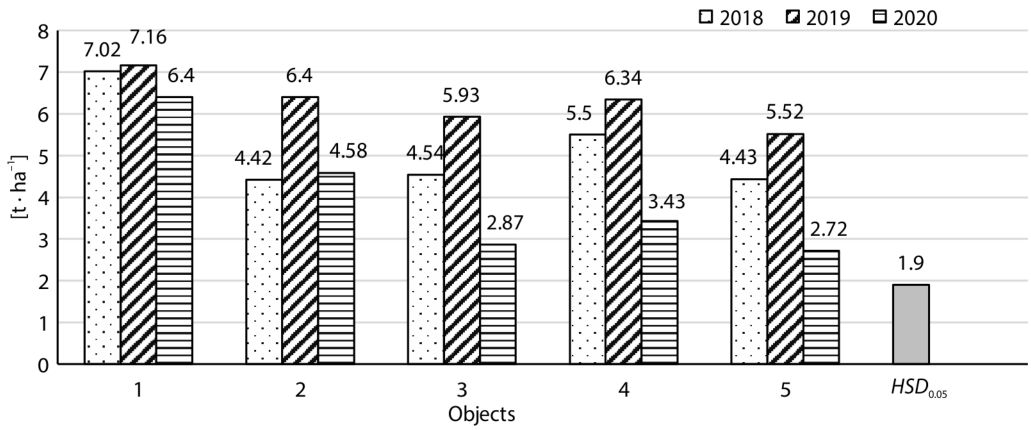

Fig. 3. Effects of the application of biostimulants and herbicide and years of study on the mass of small tubers and tubers with defects

Conclusions

All studied biostimulants PlonoStart, Aminoplant and Agr-Sorb Folium applied with herbicide Avatar 293 ZC (clomazone and metribuzin) in the potato plantation statistically reduced: share of tubers with external defects, mass of tubers with defects, share of small tubers in yield and total weight of small tubers and tubers with defects compared to the control object. The best results in reducing the occurrence of tubers with external and internal defects and small tubers were obtained by using the biostimulant containing total amino acids-13.11%, free amino acids-10.66% and herbicide Avatar 293 ZC. Of the cultivated cultivars, Malaga cv. was more resistant to physiological and mechanical external impacts and the production of small tubers than Oberon cv. The occurrence of defects and the share of small tubers in the yield were shaped by weather conditions. The lowest potato side yield (total mass tubers with defects and small tubers) was recorded in 2020, which was moderately warm and the wettest year, with a hydrothermal coefficient of 1.05.

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