AGRONOMY SCIENCE
wcześniej – formerly
Annales UMCS sectio E Agricultura
VOL. LXXVIII (2) 2023

https://doi.org/10.24326/as.2023.5091

[1] Institute of Agriculture and Horticulture, Siedlce University of Natural Sciences and Humanities, Prusa 14, 08-110 Siedlce, Poland
[2] Department of Dieteties Pope John Paul II University of Applied Sciences, Sidorska 95/97, 21-500 Biała Podlaska, Poland
* e-mail: agnieszka.ginter@uph.edu.pl

KRYSTYNA ZARZECKA[1], AGNIESZKA GINTER[1]*, MAREK GUGAŁA[1], IWONA MYSTKOWSKA[2]

Economic aspects of edible potato cultivation depending on the method of plantation protection against weeds

Ekonomiczne aspekty uprawy ziemniaka jadalnego w zależności od sposobu pielęgnacji plantacji przed chwastami

Summary. The rationale for farming, including the edible potato, is to achieve the desired economic effect. A frequently used measure in economic analysis is the gross margin. It is calculated on the basis of the production achieved and the direct costs incurred. One of the main production costs is the cost of agricultural inputs related to, among other things, the care of plantations against weeds, which can be mechanical, chemical or mechanical-chemical. The purpose of the paper was comparison of the production and economic results of edible potato cultivar Eurostar in the period of two years (2021 and 2022) including two different ways of plantation care against weeds. The first object included mechanical treatments – weeding performed three times: before emergence, 2 times dunging and 1 time dunging after emergence combined with a weeder. The second method of plantation care included double dunging and herbicide application – Avatar 293 ZC. Before emergence, weeding was applied twice and immediately after the last weeding – about 7 days before the appearance of the first potato plant emergence a chemical treatment with the herbicide at a dose of 1.5 dm^3 ha^{-1} was applied. The research material consisted of tubers of edible potato Eurostar cultivar from a two-year field experiment. Mechanical and chemical treatments provided both higher yields and a level of profitability of studied edible potato.

Key words: mechanical-chemical treatments, herbicide, costs, profitability

Citation: Zarzecka K., Ginter A., Gugała M., Mystkowska I., 2023. Economic aspects of edible potato cultivation depending on the method of plantation protection against weeds. Agron. Sci. 48(2), 33–42. https://doi.org/10.24326/as.2023.5091

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an annual, herbaceous, tuber crop of family *Solanaceae* and potato is the world's leading vegetable crop [Qasim et al. 2013]. Potatoes are grown on all continents, mostly in Asia and Europe. These two continents account for more than 80% of the world's potato-growing area [Dzwonkowski 2017]. Potato is an economically important staple crop prevailing all across the world with successful large-scale production, consumption, and affordability with easy availability in the open market. Potatoes provide basic nutrients such as carbohydrates, dietary fiber (skin), several vitamins, and minerals, e.g., potassium, magnesium, iron [Zaheer and Akhtar 2016]. Potato is an important food source [Noonari et al. 2016]. Europe has o long tradition of potato production and use [Goffart et al. 2022]. Polish potato has and can have a good prospect, but only among professionals [Nowacki 2020]. The ultimate and fundamental goal of potato production by Polish farmers is the economically profitable sale of the harvest [Nowacki 2018]. An important aspect in conducting agricultural activities is to obtain a favorable (as high as possible) economic effect, which can be, among other things, the gross margin, which is most often used in economic analysis concerning agricultural production [Skarżyńska 2017]. The chemical and mechanical-chemical method, thanks to chemical means of protection, of plants prevents the loss of crop yields and is now the basis of protection for most crops in the world [Stobiecki 2016].

The aim of the study was comparison of the production and economic results of edible potato cultivar Eurostar in the period of two years (2021 and 2022) including two different ways of plantation care against weeds In this paper it was hypothesized that mechanical-chemical protection of edible potato against weeds achieves better production and economic results than mechanical protection only.

MATERIAL AND METHODS

The material for the study consisted of yields of edible potato tubers of the Eurostar cultivar collected from a two-year field experiment carried out in 2021 and 2022 at the Agricultural Experimental Station in central Poland (52°03'N, 22°33'E). The experiment was single-factorial in three replicates established by the randomized block method: two ways of plantation protection were studied (object 1 and 2). The plot size for harvesting edible potato tubers was 12.96 m^2 (4.8 m × 2.7 m). Soil analysis was carried out in each year of the study. Differences were recorded in soil pH 5.25–5.42 (in KCl), in organic matter content 20.9–22.3 g kg^{-1} and in bioavailability in macronutrients in mg kg^{-1}: phosphorus 35.2–71.0, potassium 102.1–149.0 and magnesium 36.6–61.0. The experiment was conducted on light soil.

The forecrop for the cultivated crop was winter triticale. In autumn, manure was applied at a dose of 25.0 t ha^{-1} and mineral fertilization with phosphorus and potassium (P – 44.0 kg ha^{-1}; K – 124.5 kg ha^{-1}). Nitrogen fertilization at a dose of N – 100.0 kg ha^{-1} was applied in the spring. Class A seed potatoes, with a caliber of 35–55 mm, were planted by hand in the third decade of April. Two ways of plantation protection against weeds were used in the experiment: object 1 – the first way, which included only mechanical treatments, object 2 – the second way combining mechanical and chemical treatments (Avatar 293 ZC containing two active substances: clomazone 60 g dm^{-3} and metribuzin 233 g dm^{-3}). The first way of plantation protection in the cultivation of

edible potato included dung treatments performed three times: before emergence twice dung and after emergence once dung combined with a weeder. The second method of plantation care (object 2) included double dunging and the application of herbicide immediately after the last dunging, about 7 days before the appearance of the first emergence of potato plants at a dose of 1.5 dm^3 ha^{-1}. The selection of plant protection products were in accordance with the recommendation of the Institute of Plant Protection – National Research Institute. Against potato beetle the following preparations were used: Decis Mega 50 EW and Coragen 200 SC, while Infinito 687.5 SC, Cabrio Duo 112 EC and Carial Star 500 SC were applied against potato blight. Potato tubers were harvested in the second decade of September, during the harvest their weight was determined, and then the yield per hectare was calculated. The value of production per hectare of crop, production costs and gross margin (without payment) were calculated in accordance with the guidelines of the Institute of Agricultural and Food Economics – National Research Institute in Warsaw [Skarżyńska 2008, 2017]. In addition to the direct margin, a direct profitability index and a direct cost efficiency index were calculated. The value of production and direct production costs were calculated on the basis of current (market) prices in the analyzed years and expressed in nominal terms in EUR. The exchange rate of the euro was taken at 4.5902 PLN in 2021 and 4.6899 PLN according to the National Bank of Poland (as of the end of 2021 and 2022). The price of edible potato (trade yield) in 2021 was set at 163.39 EUR t^{-1}, and in 2022 at 181.24 EUR t^{-1}, and the price of waste (side yield) at 32.68 EUR t^{-1} in 2021 and at 31.98 EUR t^{-1} in 2022. The set of machinery used in the field experiment included: a Bomet P-475 weeder-rotor, an AKPIL KM-180-R plough, a UNIA Grudziądz U 149 cultivator, a P-329/4 mounted sprayer, an FDI-M03L fertiliser spreader and a Z-609 elevator digger. The production results of the study depending on two ways of plantation care against weeds (of each year) were subjected to analysis of variance and the significance of differences between the data (the total and the trade yield) was determined by the Tukey test at the significance level of $p \leq 0.05$ [Trętowski and Wójcik 1991].

RESULTS

Using two different methods of protecting edible potato plantations against weeds, clear differences were noted in the level of harvested yield of the tested Eurostar cultivar (Tab. 1). The research carried out led to the conclusion that both, total and trade yields were higher with mechanical and chemical weed control than with mechanical treatments only.

Table 1. Potato yield level (in t ha^{-1}) of Eurostar cultivar in 2021 and 2022 and share (in %) trade yield in total yield depending on ways of plantation care against weeds (objects 1 and 2)

Specification	2021			2022		
	object 1	object 2	mean	object 1	object 2	mean
Total yield	39.4[a]	46.6[b]	43.0[b]	33.1[a]	37.2[a]	35.2[a]
Trade yield	33.0[a]	38.8[b]	35.9[b]	26.0[a]	29.4[a]	27.7[a]
Share of trade yield in total yield	83.8	83.3	83.6	78.5	79.0	78.8

Object 1 – mechanical treatments, object 2 – mechanical-chemical treatments; a, b – significance at the level $p \leq 0.05$

In the first year of the study (2021) the increase of trade yield was about 18%, and in the second year of the study (2022) was about 12%. In 2021, total and trade yields with herbicide application were significantly different from the results obtained with mechanical treatment only. In 2022, the yields were higher, but no significant variation was found. Significant differences were also found for the methods used in the cultivation of edible potatoes in the years of study. The yield results obtained underscore the rationality of combining mechanical and chemical treatments.

Table 2. Meteorological conditions during the vegetation seasons of Eurostar cultivation

Specification	The months					
	April	May	June	July	August	September
air temperature (°C)						
2021	6.6	12.4	20.4	22.7	17.1	12.9
2022	5.2	13.6	19.9	19.3	21.0	11.7
Multiannual mean 1980–2009	7.8	12.5	17.2	19.2	18.5	13.1
precipitation (mm)						
2021	42.0	29.5	33.8	50.0	95.4	42.1
2022	31.5	31.1	26.5	95.7	39.3	64.9
Multiannual mean 1980–2009	38.6	44.1	52.4	49.0	43.0	47.7

Comparing the first year of the experiment with the second one, it should be noted that the average magnitudes of both, air temperature and rainfall in the production seasons studied were at a similar level (Tab. 2). Analyzing the distribution of air temperature in the given months of both compared seasons of Eurostar edible potato production, no differences were found. However, comparing the distribution of rainfall, it was noted that it was uneven. A particular expression of this occurred in the months: July, August and September. The year 2021 was characterized by a more favourable distribution of rainfall during the growing season. In August, during the time of intensive tuber growth, the sum of rainfall was more than 2 times higher than in 2022, which resulted in higher yields in the first year of the study. The atmospheric conditions in 2021 year were more favourable for the growth and development of potato plants in comparison with the second research year.

The direct production costs (object 1 and 2) were found to increase in the compared years of the study, about 7% (Tab. 3). This was due to an increase of the mineral fertilizers price, the costs of which in 2022 were almost twice as high as in the first year of the study. In the case of other types of costs, no such clear differences were noted.

Table 3. The direct costs (in EUR ha^{-1}) of Eurostar cultivar production in 2021 and 2022 depending on ways of plantation care against weeds (objects 1 and 2)

Type of direct costs	Years of research			
	2021		2022	
	object 1	object 2	object 1	object 2
Seed	1198.2	1198.2	1172.7	1172.7
Manure (50%)	326.8	326.8	319.8	319.8
Total mineral fertilization	164.0	164.0	325.6	325.6
Pesticides: – herbicide – insecticides – fungicides	 0.0 24.5 113.3	 133.2 24.5 113.3	 0.0 24.0 110.9	 148.2 24.0 110.9
Total direct costs	1826.8	1960.0	1953.0	2101.2
Mean in years	1893.4		2027.1	

Object 1 – mechanical treatments, object 2 – mechanical-chemical treatments

Analyzing the direct production costs of the studied cultivar grown according to two different methods of weed control in a given year (2021 and 2022), it should be noted that they were at a very similar level. The seed costs had the largest share in the direct cost structure (Tab. 4).

Table 4. The direct costs structure (in %) of Eurostar cultivar production in 2021 and 2022 depending on ways of plantation care against weeds (objects 1 and 2)

Specification	Years of research			
	2021		2022	
	object 1	object 2	object 1	object 2
Seed	65.6	61.1	60.0	55.8
Manure (50%)	17.9	16.7	16.4	15.2
Mineral fertilization	8.9	8.4	16.7	15.5
Pesticides – herbicide – insecticides – fungicides	7.6 0.0 1.4 6.2	13.8 6.8 1.2 5.8	6.9 0.0 1.2 5.7	13.5 7.1 1.1 5.3
Total direct costs	100.0	100.0	100.0	100.0

Object 1 – mechanical treatments, object 2 – mechanical-chemical treatments

In the first year of the study, in the second place in the structure under discussion were the costs of natural fertilizer – the manure (objects 1 and 2), and in the second of the study, the costs of mineral fertilisers. The increasing costs of mineral fertilizers in the second year of the study influenced changes in the direct cost structure. The varying

share of the cost of plant protection products was due to the methodology of the experiments. Among the preparations used, insecticides accounted for the smallest share. The herbicide used on the second object (2) increased direct costs by around 7%.

Table 5 has been presented the data of production and economic results depending on the two ways of plantation care against weeds (objects 1 and 2).

Table 5 has been presented the data of production and economic results depending on the two ways of plantation care against weeds (objects 1 and 2).

Table 5. Production and economics results (in EUR ha^{-1}) of Eurostar cultivar in 2021 and 2022 depending on ways of plantation care against weeds (objects 1 and 2)

Specification	Years of research			
	2021		2022	
	object 1	object 2	object 1	object 2
Value of trade yield	5391.9	6339.5	4712.2	5328.5
Value of side yield	209.2	254.9	227.1	249.4
Value of total production	5601.1	6594.4	4939.3	5577.9
Direct costs	1826.8	1960.0	1953.0	2101.2
Gross margin	3774.3	4634.4	2986.3	3476.7
Direct profitability index (%)	306.6	336.5	252.9	265.5
Direct cost efficiency index (EUR)	3.07	3.36	2.53	2.65

Object 1 – mechanical treatments, object 2 – mechanical-chemical treatments

In both years of the study, the gross margin was higher at object 2, in the first year of the study about 23%, and in the second one – about 16%. The most satisfactory direct profitability index was found in the first year of the study on the second object (336.5%). This year saw the highest trade yield of edible potato, which may have been related to the more favourable rainfall distribution . It can be concluded that the greatest influence on the variation in the level of direct surplus obtained from the cultivation of edible potatoes was the yield obtained. With fairly equal levels of direct costs, it was this factor that determined the profitability of this crop. In the first year of study recorded the highest value of total production per one EUR of direct costs (EUR 3.36) The better efficiency results of edible production have shown that the chemical care plantation with the application of herbicide Avatar 293 ZC against weeds was clearly justified. The combination of chemical and mechanical treatment allowed to achieve more favourable economic results through greater productivity.

DISCUSSION

Potato requires a number of maintenance treatments carefully selected according to the condition and degree of weed infestation [Zarzecka et al. 2022]. The popularity of crop protection treatments with chemical preparations is based on, among other things, the result of their ease of application and the achievement of quick results [Piwowar

2018]. Herbicides and mixtures of them had a favourable effect on increasing marketable yield compared to the control object, treated only mechanically [Baranowska et al. 2016]. The highest number of tubers with defects occurred after the application of mechanical treatment, while the lowest in combinations where mechanical-chemical treatments were applied [Zarzecka et al. 2013].

Due to the large mass of tuber yield produced, the potato requires sufficiently high fertilization [Trawczyński 2021]. The profitability of edible potato production is strongly influenced by evolving market prices for tubers [Chotkowski 2012, Rembeza 2012]. Analyzing the direct costs of edible potato production, it was found that the purchase of certified seed potatoes accounted for the largest share [Ginter et al. 2022]. Seeds and fertilizers were the main part of edible potato production costs [Sujan et al. 2017]. The probable reason for higher expenditure on cultivation of potato crop is due to higher cost of potato seed, manure and fertilizer and expensive labour [Sinha and Singh 2019]. The use of qualified seed material in agriculture determines the obtaining of a higher yield with better quality parameters [Chotkowski 2009]. Potato production costs are too great to risk using non-certified seed. Certified seed of good quality grown in the northern U.S. normally produces the largest yield [Brandenberger et al. 2017]. The most favourable economic effect, expressed in terms of the direct profitability index, in the cultivation of both potato varieties was also obtained with Sencor herbicide treatment before potato emergence [Barbaś and Sawicka 2017]. The cost-effectiveness of chemical protection treatments in potato cultivation has fluctuated [Golinowska et al. 2014]. It should be concluded that mechanical-chemical protection of edible potatoes against weeds of the Tajfun variety was more cost-effective than purely mechanical [Zarzecka et al. 2017]. Cultivation systems had the strongest effect on the share of commercial tubers and tubers of a diameter of 4–6 cm in the total yield [Sawicka et al. 2007]. The most beneficial structure of tuber mass was provided by mechanical and chemical care with the application of Sencor before the emergence of potato, because it gave the largest share of tubers in the yield, i.e. 50–60 and >60 mm in diameter, compared to the standard object with mechanical care [Barbaś and Sawicka 2019]. Potato is very susceptible to weed interference during the early growth stages due to slow emergence, and again at the end of the growing cycle when branches collapse and the canopy opens. Weed control usually is performed through a combination of physical and chemical methods [Cavalieri et al. 2018].

The level of income depends, among other things, on the yield and price of the potato [Gołaś 2016]. For the farmer-potato producer the important thing is the economics and the income obtained or the gross margin [Nowacki 2020]. The evaluation of economic potato production included direct costs, value of harvested crop and gross margin. It was observed that potato production in 2015–2016 was profitable (Owacja cultivar) [Baranowska 2018]. The Blue Congo potato resulted in the best production and economic results [Winnicki and Bogucka 2018]. The conducted research has shown that the most important factor of profitability, at a given price level, is the size of the commercial yield of tubers [Mystkowska et al. 2022]. This business on potato is still profitable to continue [Setiawan and Inayati 2020].

CONCLUSIONS

1. On the basis of the results of our own research, it was found that the factor differentiating the level of the profitability of edible potato production was the methods of cultivation.

2. In both years of the study, the mechanical-chemical treatment of potato plantations against weeds provided greater production and economic results of the cultivated potato in comparison to mechanical only treatments. In 2021, the total edible potato yield was 18.3% higher and in 2022 12.4% higher. The level of gross margin of the tested variety Eurostar, according to the tested years, was 22.8% and 16.4% higher.

3. On the basic of production and economic results, it was found that the highest cost-effectiveness was the cultivation variant with the application of the Avatar 293 ZC herbicide in the first year of the study. Meteorological conditions in 2021 were more favourable for edible potato yielding.

REFERENCES

Baranowska A., 2018. Profitability of edible potato production – analysis on the plantation level. Ann. Pol. Assoc. Agric. Aribus. Econ. 20(2), 16–21. https://doi.org/10.5604/ 01.3001. 0011.8110

Baranowska A., Zarzecka K., Mystkowska I., Gugała M., 2016. Efekt ekonomiczny mechaniczno-chemicznej pielęgnacji ziemniaków [Economic effect of mechanical and chemical cultivation of potatoes plantation]. Ann. Pol. Assoc. Agric. Aribus. Econ. 8(2), 27–32 [in Polish].

Barbaś P., Sawicka B., 2017. Porównanie opłacalności różnych sposobów regulacji zachwaszczenia w uprawie ziemniaka jadalnego [Comparison of profitability of different weed control in potato cultivation]. Prob. Inż. Rol. 2(96), 5–15 [in Polish].

Barbaś P., Sawicka B., 2019. The influence of methods of potato weed control and meteorological conditions on shaping the tuber yield structure. Agron. Sci. 74(3), 33–45. https://dx.doi.org/ 10.24326/as.2019.3.3

Brandenberger L., Shrefler J., Rebek E., Damicone J., 2017. Potato production. Oklahoma Coop. Exten. Service. HLA-6028, 1–4.

Cavalieri A., Paolini R., Mirabelli C., 2018. Yield and competitive ability in potato cultivars characterised by different developmental timing. Weed Res. 58, 121–130. https://doi.org/ 10.1111/wre.12293

Chotkowski J., 2009. Czynniki kształtujące zużycie kwalifikowanego materiału nasiennego w rolnictwie (na przykładzie ziemniaka) [Factor shaping the use of certified seed material In agriculture (e.g. potato)]. Stud. Rap. JUNG – PIB w Puławach 17, 129–137 [in Polish]. https://doi.org/10.26114/sir.iung.2009.17.09

Chotkowski J., 2012. Funkcjonowanie rynku i marketing w produkcji ziemniaka [Market functioning and marketing in potato production]. In: J. Chotkowski (red.), Produkcja i rynek ziemniaka [Potato production and market]. Wieś Jutra, 31–45 [in Polish].

Dzwonkowski W., 2017. Ewolucja produkcji ziemniaków w Polsce i UE [Evolution in potato production in Poland and in the EU]. Zesz. Nauk. Szk. Gł. Gospod. Wiej. Warsz., Probl. Rol. Światowego 17(3), 71–80 [in Polish]. https://doi.org/10.22630/PRS.2017.17.3.54

Ginter A., Zarzecka K., Gugała M., 2022. Effect of herbicide and biostimulants on production and economics results if edible potato. Agronomy 12(6), 1409. https://doi.org/10.3390/agronomy/ 12061409

Goffart J.P., Haverkort A., Storey M., Haase N., Martin M., Lebrun P., Ryckmans D., Florins D., Demeulemeester K., 2022. Potato production in Northwestern Europe (Germany, France, the Netherlands, United Kiongdom, Belgium): characteristics, issues, challenges and opportunities. Potato Res. 65(3), 503–547. https://doi.org/10.1007/s11540-021-09535-8

Golinowska M., Wiciak T., Kruszyński M., Adamska H., 2014. Intensywność nakładów na chemiczną ochronę roślin w gospodarstwie indywidualnym [Intensity of expenditures on chemical plant protection in individual farms]. Ann. Pol. Assoc. Agric. Aribus. Econ. 16(1), 50–56 [in Polish].

Gołaś Z., 2016. Ekonomika, organizacja i sytuacja dochodowa gospodarstw rolnych krajów Unii Europejskiej ukierunkowanych na produkcję roślin okopowych [Economics, organization and income situation of EU countries' farms focused on root crops production]. Rocz. Nauk. Ekon. Rol. ROW. 103(1), 35–45 [in Polish].

Mystkowska I., Zarzecka K., Gugała M., Sikorska A., 2022. Profitability of using herbicide and herbicide with biostimulators in potato production. J. Ecol. Eng. 23(4), 223–227. https://doi.org/10.12911/22998993/146687

Noonari S., Wagan H., Memon I.N., Ahmed F., 2016. Economic analysis of potato production in Sindh Pakistan. J. Bio. Agri. Healt. 6(5), 100–108.

Nowacki W., 2018. Innowacyjność i optymalizacja procesów przygotowania i sprzedaży ziemniaków w różnych segmentach rynkowych [Innovation and optimalization of preparation processes and selling potato in defferent market segments]. Ziem. Pol. 28(3), 3–12 [in Polish].

Nowacki W., 2020. Profesjonalna produkcja ziemniaka [Professional potato production]. CDR w Brwinowie, Brwinów [in Polish] .

Piwowar A., 2018. The consumption of mineral fertilizers and herbicides in Poland against the Background of the European Union. *Ze*sz. Nauk. Szk. Gł. Gospod. Wiej. Warsz., Probl. Rol. Światowego 18(33), 194–202. https://doi.org/ 10.22630/PRS.2018.18.1.18

Qasim M., Khalid S., Naz A., Khan. M.Z., 2013. Effects of different planting systems on yield of potato crop in Kaghan Valley: A mountainous region of Pakistan. Agric. Sci. 4(4), 175–179. http://dx.doi.org/10.4236/as.2013.44025

Rembeza J., 2012. Czynniki kształtujące koszty i opłacalność w produkcji ziemniaka [Factors shaping the cost and profitability of potato production]. In: J. Chotkowski (red.), Produkcja i rynek ziemniaka [Potato production and market]. Wieś Jutra, Warszawa, 21–30 [in Polish].

Sawicka B., Barbaś P., Kuś J., 2007. Varibility of potato yield and its structure in organic and integrated crop production systems. Electron. J. Pol. Agric. Univ., Ser. Agron. 10(1), #02. http://www.ejpau.media.pl/volume10/issue1/art-02.html

Setiawan A.B., Inayati C., 2020. The analysis of production factors and income of potato farming. J. Econ. Pol. 13(1), 17–29. https://doi.org/10.15294.jejak.v13i1.21965

Sinha A.K., Singh S.K., 2019. Economics of potato production in Northern Hills of Chhattisgarh. Econ. Aff. 64(1), 1–7. https://doi.org/10.30954/0424-2513.1.2019.1

Skarżyńska A., 2008. Założenia metodyczne [Methodological assumptions]. In: A. Skarżyńska (red.), Produkcja, koszty i nadwyżka bezpośrednia wybranych produktów rolniczych w 2007 roku [Production, costs and gross margin of selected agricultural products in 2007]. IERiGŻ w Warszawie, Warszawa, 9–19 [in Polish].

Skarżyńska A., 2017. Costs and profitability. Zag. Ekon. Rol. 2(351), 178–203. https://doi.org/ 10.30858/zer/83028

Stobiecki S., 2016. Metoda chemiczna [Chemical method]. W: S. Pruszyński (red.), Metody ochrony w integrowanej ochronie roślin [Protection methods in integrated plant protection]. CDR w Brwinowie, Brwinów, 111–126.

Sujan H.K., Islam F., Kazal M.M.H., Mondal R.K., 2017. Profitability and resources use efficiency of potato cultivation in Munshiganj district of Bangladesh. J. Agri. 15(2), 193–206. https://dx.doi.org/10.3329/sja.v15i2.35151

Trawczyński C., 2021. Assessment of mineral nitrogen fertilization of early potato varieties in integrated production. J. Elem. 26(1), 109–123. https://doi.org/10.5601/jelem.2020.25.4.2066

Trętowski J., Wójcik A.R., 1991. Metodyka doświadczeń rolniczych [Methodology of agricultural experiments]. Wyższa Szkoła Rolniczo-Pedagogiczna w Siedlcach, Siedlce [in Polish].

Winnicki T., Bogucka B., 2018. Economic assessment of the effectiveness of cultivation of edible, purple-flesh potato cv. Blue Congo. Pol. J. Agron. 32, 30–36. https://doi.org/10.26114/pja.jung.348.2018.34.04

Zaheer K., Akhtar M.H., 2016. Potato production, usage, and nutrition – a review. Crit. Rev. Food Sci. Nut. 56(5), 711–721. https://doi.org/10.1080/10408398.2012.724479

Zarzecka K., Gugała M., Dołęga H., 2013. Występowanie wad bulw ziemniaka w warunkach pielęgnacji mechaniczno-chemicznej [The occurrence of defects of potato tubers in conditions of mechanical-chemical weeding]. Nauka Przyr. Technol. 7(1), 1–8 [in Polish].

Zarzecka K., Gugała M., Mystkowska I., Baranowska A., Głuszczak B., 2017. Ekonomiczna ocena różnych sposobów odchwaszczania ziemniaków jadalnych [Economic evaluation of different systems of weed control of edible potatoes]. Ann. Pol. Assoc. Agric. Aribus. Econ. 19(3), 308–311 [in Polish]. https://doi.org/10.5604/01.3001.0010.3268

Zarzecka K., Gugała M., Mystkowska I., Sikorska A., 2022. Efektywność ekonomiczna stosowania różnych metod pielęgnacji i odżywiania roślin ziemniaka przy pomocy biostymulatorów [Economic effectiveness of using various methods of care and nutrition of potato plants with the use of biostimulants]. Prog. Plant Prot. 62(1), 11–16 [in Polish]. https://doi.org/10.14199/ppp-2022-0

The source of funding: Research task number162/23/B.

Received: 24.02.2023
Accepted: 12.06.2023
Online first: 23.06.2023
Published: 26.09.2023