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The influence of methods of potato weed control and meteorological conditions on shaping the tuber yield structure

Wpływ metod zwalczania zachwaszczenia ziemniaka i warunków meteorologicznych na kształtowanie struktury plonu bulw

Summary. The test results were based on a field experiment conducted in 2007–2009 in a pilot plant IHAR – PIB in Jadwisin on lessive soil granulometric composition of loamy sand. Experiment was covered with the method of drawn subblocks in the dependent arrangement, split-plot, in three repeating. Order factor were cultivars of potato, ‘Irga’ and ‘Fianna’, factor II row weed control methods were: (1) object control – without chemical protection; (2) extensive mechanical treatments (every 2 weeks) after planting until short rows; (3) Sencor 70 WG – 1 kg·ha^{-1} pre-emergence potato; (4) Sencor 70 WG – 1 kg·ha^{-1} + Titus 25 WG – 40 g·ha^{-1} + Trend 90 EC – 0.1% pre-emergence potato; (5) Sencor 70 WG – 0.5 kg·ha^{-1} after emergence potatoes; (6) Sencor 70 WG – 0.3 kg·ha^{-1} + Titus 25 WG – 30 g·ha^{-1} + Trend 90 EC – 0.1% after emergence potatoes; (7) Sencor 70 WG – 0.3 kg·ha^{-1} + Fusilade Forte 150 EC – 2 dm^{3}· ha^{-1} after emergence potatoes; (8) Sencor 70 WG – 0.3 kg·ha^{-1} + Apyros 75 WG 26.5 g·ha^{-1} + Atpolan 80 SC – 1·dm^{3} ha^{-1} after emergence of the potato. Spray the plants with herbicides was consumed 300 dm^{3}·ha^{-1} water. Harvest tubers were performed on technical maturity of the potato. During the harvest, tubers samples were taken from each plot to assess the yield structure. The ‘Fianna’ cultivar was characterized by a more favourable yield structure, characterized by a higher share of large tubers, in their total weight. Thermal and humid conditions had a significant effect on the potato yield structure. The most beneficial structure of the mass of tubers was provided by mechanical and chemical care with the application of Sencor before the emergence of potato, because it gave the largest share of bulbs in the yield, i.e. 50–60 and >60 mm in diameter, compared to the control object.

Key words: potato, cultivars, weeding control methods, herbicides, seed potato, meteorological conditions

INTRODUCTION

Many quantitative and qualitative characteristics of potato are conditioned not only genetically, but also environmentally. The most important reasons for this variability include: quality of seed potatoes (health, size, storage) [Gildemaher et al. 2009, Fajardo et al. 2010, Kawakami et al. 2015, Urrea-Hernandez et al. 2016], nonuniformity of the soil environment (soil variability, pH) [Sawicka et al. 2007, Hirpa et al. 2010, Muthoni and Kabira 2010], diversity of the impact of meteorological conditions, such as rainfall, humidity, temperature, light (wavelength, intensity and duration) [Abdrabo et al. 2010, Mondani et al. 2011, Dzieżyc et al. 2012, Chmura et al. 2013, Kołodziejczyk 2013, Yang et al. 2018]. An important factor limiting the potato yield and its structure is weeds [Pszczółkowski and Sawicka 2003, Sawicka et al. 2007, Tomar et al. 2008, Wichrowska 2008, Barić and Ostoijć 2013, Zarzecka et al. 2013, Baranowska et al. 2016, Gugała et al. 2017, 2018a, b]. Choosing the right method of weed control can ensure a high yield, with a large share of the largest tubers, as well as facilitate potato harvesting. Therefore, the aim of the research was to assess the effect of weed control on the yield structure of the tested potato cultivars.

MATERIAL AND METHODS

Results of the research were based on a field experiment carried out in 2007–2009 at the Plant Breeding and Acclimatization Institute – National Research Institute in Jadwisin (52°29'N, 21°03'E), on podzolic soil, granulometric composition of light loamy sand, rye complex good bonitation class IVb [WRB 2014]. Soil acidity ranged from acidic (4.7 pH) to slightly acidic (5.4 pH). The experiment was established using a random subblock method in a dependent, split-plot system, in triplicate. Two factors were investigated in the experiment: 1st order factors were potato cultivars: ‘Irga’ and ‘Fianna’, and 2nd order factor were ways to regulate weed infestation: (1) control object – without chemical protection; (2) extensive mechanical treatments (every 2 weeks) from planting to row compaction; (3) Sencor 70 WG – 1 kg·ha^{-1} before the potato emergence; (4) Sencor 70 WG – 1 kg·ha^{-1} + Titus 25 WG – 40 g·ha^{-1} + Trend 90 EC – 0.1% before the potato emergence; (5) Sencor 70 WG – 0.5 kg·ha^{-1} after the potato emergence; (6) Sencor 70 WG – 0.3 kg·ha^{-1} + Titus 25 WG – 30 g·ha^{-1} + Trend 90 EC – 0.1% after the potato emergence; (7) Sencor 70 WG – 0.3 kg·ha^{-1} + Fusilade Forte 150 EC – 2 dm^3·ha^{-1} after the potato emergence; (8) Sencor 70 WG – 0.3 kg·ha^{-1} + Apyros 75 WG 26.5 g·ha^{-1} + Atpolan 80 SC – 1 dm·ha^{-1} after the potato emergence. 300 dm^3·ha^{-1} water was used to spray the plants with herbicides. The forecrop of potato was winter wheat, after harvesting of which the post-crop of white mustard for plowing was used. Metribuzin was used in the form of Sencor 70 WG, sulfosulfuron – in the form of Apyros 75 WG, rimsulfuron – in the form of the herbicide Titus 25 WG, fluazifop – in the form of Fusilade Forte 150 EC. The forecrop of potato was winter wheat, after harvesting of which the white mustard for plowing (20 kg·ha^{-1}) was sown. After the wheat harvest, nitrogen fertilization was applied – 50 kg N·ha^{-1}, stubble cultivation was performed and white mustard seed was sown in the amount of 20 kg·ha^{-1}. White mustard, as a green fertilizer for plowing, brought on average the following quantities of chemical components each year: dry matter – 454 g, ash – 55.1 g, total N – 19.2 g, mineral N – 0.8 g, phosphorus (P) – 3.1 g, potassium (K) – 31.6 g, magnesium (Mg) – 4.5 g, sodium (Na) – 0.8 g, copper (Cu) – 0.40 mg, cadmium (Ca) – 1.29 mg, chromium (Cr) – 14.6 mg, nickel (Ni) – 7.05 mg, zinc (Zn) – 35.4 mg, manganese (Mn) – 36.0 and iron (Fe) – 63.4 mg kg^{-1} of white mustard dry matter. Moreover, in the autumn of each year preceding the planting, mineral phosphorus-potassium fertilization was applied in the amount of 39.3 kg $P \cdot ha^{-1}$ and 116.2 kg $K \cdot ha^{-1}$, which were plowed with pre-winter plowing. Nitrogen fertilizers were sown in the spring, in the amount of 100 kg $N \cdot ha^{-1}$, by mixing them with the soil using a cultivating unit (cultivator + string roller). Potato tubers were planted manually, at the end of April, with a spacing of 75 × 33 cm. The propagating material was in the C/A class. Herbicide spraying was done manually using a backpack sprayer. The protection of the potato against diseases and pests was applied in accordance with the IOR recommendations. The following preparations were used to protect against alternariosis and late blight: Tattoo C 750 SC at a dose of 2.5 $dm^3 \cdot ha^{-1}$, Altima 500 SC – 0.4 $dm^3 \cdot ha^{-1}$, Python 60 WG – 1.25 $kg \cdot ha^{-1}$, Ridomil Gold MZ 60 WG – 2.5 $kg \cdot ha^{-1}$. In order to reduce the potato beetle, insecticides were used: Actara 25 WG at a dose of 0.4 $kg \cdot ha^{-1}$, Proagro 100 SL – 0.25 $dm^3 \cdot ha^{-1}$, Calypso 480 SC – 0.75 $dm^3 \cdot ha^{-1}$ and Mospilan 20 SP in the amount of 0.05 $kg \cdot ha^{-1}$. The use of pesticides was in line with the IOR-PIB recommendations.

Before starting the experiment, in each year of research, soil samples were taken for physicochemical analyses. Soil acidity was determined in a 1 M solution of $KCl \cdot dm^{-3}$. Granulometric composition of the soil was determined using the areometric method by Prószyński [Ryżak et al. 2009]. The content of available forms of phosphorus and potassium was determined by the Egner-Riehm and magnesium method – by Schatschabel. The Tiurin method was used to determine the carbon content and, indirectly, humus in the soil [Mocek 2015].

The harvest of tubers was carried out by elevator digger at the end of September. During the harvest, representative samples of tubers (tubers from 10 bushes of each plot) were collected from each plot to determine the yield and its structure. The yield structure, divided into tuber fractions with a diameter of less than 35, 35–50, 50–60 and above 60 mm, was determined by calculating the share of weight and number of tubers of individual fractions in the yield; whereas tuber fractions with a diameter of >35 mm were treated as commercial yield, whereas those with a diameter of 35–50 mm – as the yield of seed potatoes, excluding tubers damaged mechanically, green and with visible physiological defects [Roztropowicz 1999, Rozporządzenie Ministra RiRW z 2003 r.].

Statistical calculations were made using the SAS ver. 9.2 package. Statistical analyses were based on three-factor analysis of variance (ANOVA) model and multiple tests (or confidence intervals) of t-Tukey, with significance level $p = 0.05$. Significance of the variability sources was tested by Fischer-Snedecor F test for the attributes expressed in per cents around 0 or 100; normalization transformations were applied as logarithmic transformation, and after the calculations data were retransformed. Logarithmic transformations of the random positive variable *x*, were calculated according to the formula: $y(x) = \ln(x)$ [Koronacki and Mielniczuk 2006]. To characterize the thermal and humidity conditions in the years of research, data of the Meteorological Station located on the area of the Plant Breeding and Acclimatization Institute – National Research Institute in Jadwisin, were used. The month classification was based on the obtained Sielianinov coefficient, proposed by Skowera et al. [2014]. It enabled the isolation of extremely dry and extremely humid conditions. Conditions of the growing season in 2007–2009 were characterized by diversified air and rainfall temperatures (Tab. 1).

Table 1. Hydrothermal coefficients of Sielianinov during the potato vegetation period in 2007–2009 according to the meteorological station in Jadwisin

Month	Years		
	2007	2008	2009
April	0.6	1.3	0.0
May	1.9	1.6	2.1
June	2.3	0.8	1.3
July	0.9	1.2	1.2
August	1.3	1.4	1.5
September	3.2	1.4	0.4

Ranges of values of this index were classified according to Selianinov as: extremely dry − $k \le 0.4$; very dry − $0.4 < k \le 0,7$; dry − $0.7 < k \le 1.0$; fairly dry − $1.0 < k \le 1.3$; optimum − $1.3 < k \le 1.6$; fairly humid − $1.6 < k \le 2.0$; wet − $2.0 < k \le 2.5$; very humid − $2.5 < k \le 3.0$; extremely humid − $k > 3.0$

Source: date form meteorological station in Jadwisin

According to the Sielianinov hydrothermal coefficient, which ranged from 0.8 to 2.3, the potato vegetation period was classified as wet (2007), dry (2008) and optimal (2009). In 2007, in April and July, drought was recorded, while the remaining months were humid. The year 2008 was characterized by optimal moisture content, however, in June when the crop was accumulated, dry conditions prevailed. In 2009, during the planting and harvesting period, drought was recorded, while in the remaining months of the growing season, the conditions were moist.

The soil granulometric analysis shows that the sands fraction was 66.97%, dust – 30.58%, and clays – 2.45% (Tab. 2), which corresponds to the composition of light loamy sand [WRB 2014, Mocek 2015].

Table 2. Granulometric composition of soil

Year	Composition content of the granulometric fractions (%)									Soil classification
	sand					silt			loam	
	2.0–1.0 mm	1.0–0.5 mm	0.5–0.25 mm	0.25–0.10 mm	0.10–0.05 mm	0.05–0.02 mm	0.02–0.005 mm	0.005–0.002 mm	< 0.002 mm	
2007	0.10	16.58	29.56	12.05	8.61	16.02	11.17	3.30	2.61	sandy loam
2008	0.98	17.86	28.27	11.75	8.33	15.40	11.16	3.56	2.69	sandy loam
2009	0.71	15.09	25.39	13.59	14.05	18.48	10.27	2.37	2.05	sandy loam
Average	0.60	16.51	27.07	12.46	10.33	16.63	10.87	3.08	2.45	–

Own research based on designations at the Chemical-Agricultural Station in Wesoła near Warsaw

Table 3. Physical and chemical properties of soil in Jadwisin (2007–2009)

Years	Content of assimilable Macronutrients (mg·100 g^{-1} soil)			pH (1M KCl)	Humus (%)
	P	K	Mg		
2007	10.4	18.4	12.1	4.7	0.73
2008	4.3	13.9	9.3	5.4	0.68
2009	1.7	6.1	3.6	5.0	0.70
Average	5.5	12.8	8.3	5.0	0.70

Own research based on designations at the Chemical-Agricultural Station in Wesoła

In terms of agricultural suitability, this soil is included in the rye complex, bonitation class IVb, with an acidic to slightly acidic pH (4.7 to 5.4 pH in 1M KCl) (Tab. 3). This soil was defined as medium, dusty one [Mocek 2015]. The content of organic matter in the arable layer was low and ranged from 0.68 to 0.73%. Soil's abundance in available phosphorus ranged from very low (2009) to very high (2007). The soil's abundance in available forms of potassium was also characterized by considerable variability in the years of research and ranged from low to high. The average abundance of available magnesium was found in the soil collected for analysis in 2009, and very high in 2007 (Tab. 3) [Lipiński 2016].

RESULTS

All experimental factors shaped the tuber yield structure. The largest fraction of the yield was made up by tubers with a diameter of 50–60 mm, the smallest – tubers with caliber >35 mm. The 'Fianna' cultivar was characterized by more favorable yield structure characterized by higher share of large tubers in their overall weight (Tab. 4).

Ways of care also differentiated the tuber yield structure (Tab. 4). 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 control object. Other methods of care significantly increased the participation of tubers with a diameter of 50–60 mm, with the exception of object with the addition of Sencor + Apyros + Atpolan 80 S.C. preparations after potato emergence, in relation to the control object. Mechanical cultivation of potato also significantly influenced the improvement of the yield structure, significantly increasing the participation of tubers with a diameter of 5–6 cm, and reducing the share of small and medium tubers. The share of the largest tubers in the yield was significantly increased only in objects with mechanical and chemical care with the use of Sencor before the emergence of potato, in comparison with the control object. Meteorological conditions in 2008 allowed for the production of the largest mass of large and very large tubers in yield, while thermal humidity in 2009 were the least favorable for them. The largest number of small tubers was produced by tested cultivars in 2007, and medium tubers with a caliber of 35–50 mm in diameter – in 2009 (Tab. 4).

Table 4. The share of tuber with a diameter <35 mm, 35–50 mm, 50–60 mm and >60 mm in the total yield, depending on the cultivars, cultivation methods and years (%)

Experimental factors		The tuber fractions about diameter (mm)			
		<35	35–50	50–60	>60
Cultivars	'Irga'	7.9	54.9	27.8	9.3
	'Fianna'	6.9	50.9	35.3	6.7
	$LSD_{0.05}$	1.2	3.2	2.7	2.0
Cultivation methods*	1	15.1	57.7	22.9	4.2
	2	6.2	50.8	33.5	9.4
	3	5.9	46.4	36.2	11.5
	4	6.9	50.8	33.2	9.0
	5	6.3	56.7	32.3	6.3
	6	6.2	55.2	30.0	7.2
	7	5.7	51.0	34.7	8.7
	8	7.4	54.6	30.0	8.0
	$LSD_{0.05}$	3.7	3.2	8.5	6.5
Years	2007	11.1	53.1	30.4	5.2
	2008	6.4	43.7	35.5	14.2
	2009	4.8	61.8	28.7	4.5
	$LSD_{0.05}$	1.7	4.6	4.0	3.0
Mean		7.4	52.9	31.5	8.0

* Cultivation methods:
1. control object, without cultivars method,
2. mechanical care,
3. Sencor 70 WG − 1 kg·ha^{-1} – before the emergence of the potato,
4. Sencor 70 WG – 0.3 kg·ha^{-1} + Titus 25 WG – 40 g·ha^{-1} + Trend 90 EC – 0.1% – before emergence of potato,
5. Sencor 70 WG – 0.5 kg·ha^{-1} – after potato emergence,
6. Sencor 70 WG – 0.3 kg · ha^{-1} + Titus 25 WG – 30 g·ha^{-1} + Trend 90 EC – 0.1% – after emergence of the potato,
7. Sencor 70 WG – 0.3 kg·ha^{-1} + Fusilade Forte 150 EC – 2 dm^3·ha^{-1} after potato emergence,
8. Sencor 70 WG – 0.3 kg·ha^{-1} + Apyros 75 WG 26.5 g·ha^{-1} + Atpolan 80 SC – 1 dm^3·ha^{-1} after emergence of potato

Source: own research

The share of seed potatoes in the total yield was on average 85%, and depending on the cultivar – 82.6–87.4%, and depending on the methods of weeding – 82.5–87.4% (Tab. 5).

Studied varieties differed significantly in the proportion of tubers with a diameter corresponding to seed potatoes. The average late 'Fianna' was characterized by a larger participation of tubers with this caliber than the average early 'Irga'. Methods of care did not differentiate the share of seed potatoes in the total yield, although a higher value of this feature was observed after application of the Sencor 70 WG herbicide after the emergence of the crop plant, at a dose of 0.5 kg·ha^{-1}, in relation to the control object (Tab. 5).

Table 5. Percentage share of seed potatoes in total yield, depending on cultivars, methods of cultivation and years

Cultivars	Years	Cultivation methods*								Mean
		1	2	3	4	5	6	7	8	
‘Irga’	2007	76.9	87.5	85.7	86.9	81.4	76.3	88.1	82.9	83.2
	2008	81.2	72.2	55.7	64.7	82.9	81.4	72.0	77.2	73.4
	2009	87.9	86.4	92.3	95.7	95.5	95.7	89.2	88.9	91.4
	mean	82.0	82.0	77.9	82.4	86.6	84.4	83.1	83.0	82.6
‘Fianna’	2007	92.6	88.6	91.7	77.7	87.4	88.7	88.3	86.0	87.6
	2008	86.7	80.9	80.2	89.3	85.4	87.2	87.5	84.4	85.4
	2009	88.5	90.5	89.6	89.7	91.9	90.2	87.2	88.2	89.4
	mean	89.2	86.6	87.1	85.5	88.2	88.7	87.6	86.2	87.4
Mean for cultivars	2007	84.7	88.0	88.7	82.3	84.4	82.5	88.2	84.4	85.4
	2008	83.9	76.5	67.9	77.0	84.1	84.3	79.7	80.8	79.4
	2009	88.2	88.4	90.9	92.7	93.7	92.9	88.2	88.5	90.4
Mean		85.6	84.3	82.5	84.0	87.4	86.5	85.3	84.6	85.0

$LSD_{0.05}$	
Cultivars	1.9
Cultivation methods	ns
Years	2.8
Cultivars × cultivation methods	ns
Years × cultivars	ns
Years × cultivation methods	5.1

* designations as in table 3; ns – not significant at p = 0.05

Table 6. Yield of seed potatoes, depending on the cultivars, the methods of cultivation and years ($Mg \cdot ha^{-1}$)

Cultivars	Years	Cultivation methods*								Mean
		1	2	3	4	5	6	7	8	
Irga	2007	9.2	20.3	16.6	18.6	16.3	20.6	23.5	22.8	18.4
	2008	18.8	24.8	23.6	25.3	28.1	27.9	27.1	28.4	25.5
	2009	22.1	22.2	30.5	29.7	25.3	30.2	28.5	27.6	27.0
	mean	16.7	22.4	23.5	24.5	23.2	26.2	26.3	26.2	23.6
Fianna	2007	7.5	19.2	15.5	18.9	15.0	18.7	14.9	19.1	16.0
	2008	23.6	31.0	33.6	32.2	22.5	26.0	31.2	30.7	28.8
	2009	31.3	38.2	40.3	36.4	37.1	35.0	31.3	33.1	35.3
	mean	20.8	29.4	29.8	29.1	24.8	26.5	25.8	27.6	26.7
Mean for cultivars	2007	8.3	19.7	16.0	18.7	15.6	19.6	19.2	20.9	17.2
	2008	21.2	27.9	28.6	28.7	25.3	26.9	29.1	29.5	27.1
	2009	26.7	30.2	35.4	33.0	31.2	32.6	29.9	30.3	31.1
Mean		18.7	25.9	26.6	26.8	24.0	26.4	26.0	26.9	25.1

$LSD_{0.05}$	
Cultivars	1.4
Cultivation methods	6.7
Years	2.1
Cultivars × cultivation methods	ns
Years × cultivars	ns
Years × cultivation methods	ns

* designations as in table 3; ns – not significant at p = 0.05

Years of research have diversified the share of seed potatoes in the total yield. Their highest participation was obtained in the optimal, in terms of rainfall, 2009, while the lowest – in dry 2008 (Tab. 5). In this case, the interaction of meteorological conditions and methods of care was also observed. The highest share of seed potatoes in yield was obtained in 2009, the year optimal in every respect, in objects with post-emergence use of Sencor; in dry, 2007 – objects with pre-emergence application of this preparation, and in rather moist 2008 – in objects with post-emergence use of the Sencor + Titus + adjuvant mixture (Tab. 5).

The average theoretical yield of seed potatoes was 25.1 Mg·ha^{-1}. The value of this feature differentiated all the factors of the experiment (Tab. 6). The higher value of this feature characterized an average late cultivar 'Fianna' than medium early 'Irga'.

The highest seed potato yield, regardless of the cultivar, was obtained in object No. 8, after application of a mixture of Sencor 70 WG herbicides – 0.3 kg·ha^{-1} + Apyros 75 WG 26.5 g·ha^{-1} + Atpolan 80 SC – 1 dm^3·ha^{-1}, in comparison to the control object, while other methods of mechanical and chemical as well as mechanical care have proved to be homologous in terms of the feature discussed. In the optimal year, both in terms of precipitation and temperature, the highest yield was obtained in 2009, and in dry 2007 – the lowest seed potato yield (Tab. 6).

DISCUSSION

The share of potato tubers mass in the total yield was dependent on the method of weed control and cultivar grown. The largest number of tubers with a diameter of over 50 mm was harvested from objects using metribuzin prior to potato emergence. This is in line with results obtained by Sawicka [1994] and Gugała et al. [2013]. Wichrowska [2008] obtained the largest number of tubers with this caliber after the application of Afalon. Differences in the yield structure can be justified by physiological changes in plants, especially when using metribuzin (Sencor) after emergence [Gawroński et al. 1985, Sawicka 1994, Zagonel et al. 1999]. This herbicide inhibited the tuber formation, which was also confirmed by Correia and Carlvahro [2018]. The use of herbicide mixtures in the experiment increased the share of seed potatoes in the total yield, in comparison with the mechanical care, which is in line with results obtained by Zarzecka et al. [2013], Mystkowska et al. [2017b] and Baranowska [2018]. The authors also proved that the application of mixtures of preparations regulating the weeds increased the share of the largest tubers in yield. In potato cultivation, apart from choosing the right method of weed control and applied herbicides, the cultivar plays a large role, which is consistent with results obtained in the above experiment. Difference in tuber calibers, according to Müller et al. [2009], is associated with the group of earliness and the period of vegetation, which was reflected in previous results by Sawicka and Barbaś [2015], Sawicka [1994], Sawicka et al. [2007], Cavalieri et al. [2018], and Kumar et al. [2017]. In turn, Pszczółkowski and Sawicka [2003] proved that there are no significant differences between the groups of earliness, while the heterogeneity groups are heterogeneous within the groups of early varieties, and the genotype share in phenotypic variability was 11.4–34.1% depending on the analyzed features. The highest share in the total variability of tubers with diameter >40, 40–50, 50–60 and >60 mm, was played by thermal and precipitation conditions in the years of research, which constituted 62.4–85.0% of the total variability. The basic and indispensable element of the climate, which is characterized by high temporal and spatial variability, are atmospheric precipitation. In the domestic and foreign literature, there are many publications presenting long-term fluctuations of this weather element [Czarnecka and Nidzgorska-Lencewicz 2012, Czernecki and Mietus 2017, Minda et al. 2018, Radaković et al. 2018]. An important factor is also the air temperature [Mavromatis and Stathis 2011, Bajat et al. 2015]. The analyzed potato traits in the experiment were to a large extent determined by meteorological conditions in individual years of research. The share of tubers of the seed potato fraction was smaller in dry season than in the remaining years, in which the rainfall was higher and more preferably distributed. According to Lisowski et al. [2015], early cultivars, especially in the initial growing season, need much warmer conditions that will allow earlier planting and faster harvesting. In the studies of Sawicka and Barbaś [2015], the abundant yields of potato tubers in the western part of Lublin province were favored by the average temperature of the growing season within the limits of 14.6–14.8°C and the sum of precipitation from 400 to 450 mm, and in the eastern part of the province – temperature of 14.8–15.0°C and precipitation at the level of 350–400 mm. In the opinion of Radzka et al. [2013], the long-term drought and high summer temperatures are the factors that lower the potato yield the most.

The works of Abdrabbo et al. [2010], Klikocka and Sachajko [2011], Radzka et al. [2013], Kleinwechter et al. [2016], Mystkowska et al. [2017a] also indicate large variability of yields depending on weather conditions. According to Kalbarczyk [1999], the potato reacts with a decrease in the tuber yield, both in insufficient and excessive soil moisture, in relation to the potato water needs, which according to Kalbarczyk and Kalbarczyk [2009] are different in individual months of harvest and average for Poland: in July – 90 mm, August – 75 mm and in September – 60 mm. The demand for water should also be considered based on the specific potato cultivar grown. In the experiment carried out, the mid-late cultivar ‘Fianna’ was characterized by more favorable yield structure, and by a higher share of large tubers in the mass of the yield than medium-early ‘Irga’. According to Nowak [1989], early varieties, from planting to harvest, give the highest yields, with rainfall 250–300 mm, medium early cultivars – at 300–350 mm, and late cultivars – at 350–400 mm. The sum of rainfall during the growing season should also be considered based on the demand for water of a given species or cultivar. In the case of early potato cultivars, precipitations in the Central-Eastern region of Poland, according to Kołodziej et al. [2003], are enough to cover 79% of their needs, and in the case of late cultivars – about 91% of the rainfall needs of the potato. The water needs of potato according to Kowalik and Scalenghe [2009] reach 315 mm during the growing season, and according to Brouwer and Heibloem [1986] – in conditions of Western Europe – 500–700 mm, therefore they are twice as large. With low rainfall during the growing season of potato, reproducible in years, to obtain a crop of tubers with calibrations characteristic of commercial yield, irrigation should be used.

CONCLUSIONS

1. Genetic characteristics significantly modified the structure of tuber mass in the total yield. On average, late ‘Fianna’ was characterized by more favorable yield structure, characterized by a higher share of large tubers in their general mass, than the average early cultivar ‘Irga’.

2. 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.

3. Meteorological conditions during the growing season had the largest, significant impact on the tuber yield structure. In the year with an optimum amount and even distribution of rainfall, they allowed to produce the largest mass of commercial tubers and seed potatoes, while drought was the least favorable condition for them.

4. The potato reaction to care methods in the study years was only observed in the case of seed potatoes in the total yield. In the wet year, their highest participation in yield was obtained in objects with post-emergence care of potato using a mixture of Sencor preparation (1/3 dose) + Titus + adjuvants; in the optimal year, in terms of thermal and humid conditions – in objects with post-emergence care applying Sencor in a dose reduced by half; and in the dry year – in objects with pre-emergence application of Sencor, at full dose.

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Streszczenie. Wyniki badań oparto na doświadczeniu polowym przeprowadzonym w latach 2007–2009 w zakładzie doświadczalnym IHAR-PIB w Jadwisinie na glebie płowej, o składzie granulometrycznym piasku gliniastego. Eksperyment założono metodą losowanych podbloków w układzie zależnym, split-plot, w trzech powtórzeniach. Czynnikiem I rzędu były odmiany ziemniaka: 'Irga' i 'Fianna', czynnik II rzędu stanowiły sposoby regulacji zachwaszczenia: (1) obiekt kontrolny − bez chemicznej ochrony; (2) ekstensywne zabiegi mechaniczne, (co 2 tygodnie) od posadzenia aż do zwarcia rzędów; (3) Sencor 70 WG – 1 kg·ha^{-1} przed wschodami ziemniaka; (4) Sencor 70 WG – 1 kg·ha^{-1} + Titus 25 WG – 40 g·ha^{-1} + Trend 90 EC − 0,1% przed wschodami ziemniaka; (5) Sencor 70 WG − 0,5 kg·ha^{-1} po wschodach ziemniaka; (6) Sencor 70 WG − 0,3 kg·ha^{-1} + Titus 25 WG – 30 g·ha^{-1} + Trend 90 EC − 0,1% po wschodach ziemniaka; (7) Sencor 70 WG − 0,3 kg·ha^{-1} + Fusilade Forte 150 EC – 2 dm·ha^{-1} po wschodach ziemniaka; (8) Sencor 70 WG − 0,3 kg·ha^{-1} + Apyros 75 WG 26,5 g·ha^{-1} + Atpolan 80 SC – 1 dm·ha^{-1} po wschodach ziemniaka. Do opryskiwania roślin herbicydami zużywano 300 dm·ha^{-1} wody. Zbiór bulw przeprowadzono w fazie dojrzałości technicznej ziemniaka. Podczas zbiorów pobrano próby bulw z każdego poletka w celu oceny struktury plonu. Odmiana 'Fianna' odznaczała się korzystniejszą strukturą plonu, charakteryzującą się największym udziałem bulw dużych, w ogólnej ich masie. Najkorzystniejszą strukturę masy bulw zapewniała pielęgnacja mechaniczno-chemiczna z wniesieniem preparatu Sencor przed wschodami ziemniaka, gdyż dała największy udział bulw dużych w plonie, tj. o średnicy 50–60 i >60 mm, w stosunku do obiektu kontrolnego. Warunki termiczno-wilgotnościowe wywarły istotny wpływ na strukturę plonu bulw ziemniaka.

Słowa kluczowe: ziemniaki, odmiany, metody zwalczania chwastów, herbicydy, sadzeniaki, warunki meteorologiczne

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