

## EFFECT OF HERBICIDES ON THE CONTENT DRY MATTER AND SUGARS IN EDIBLE POTATO TUBERS

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### ABSTRACT

The research material consisted of tubers of two potato cultivars in a three-years field experiment conducted at the Zawady Experimental Station (52°03'N; 22°33'E) of the University of Natural Sciences and Humanities in Siedlce. The experiment was a split-plot design with three replication. The effect of two factors was evaluated: I - two potato cultivars (Irga and Balbina), II - four weed control methods: 1) mechanical weed control alone as a control variant; 2) combined mechanical and chemical weed control, including ridging and harrowing and twice ridging before potato emergence and treatment with herbicide Plateen 41.5 WG (metribuzin + flufenacet), at a dose of 2.0 kg ha<sup>-1</sup>, immediately before the emergence of potato plants; 3) combined mechanical and chemical weed control, comprising single ridging and treatment with herbicide Racer 250 EC (fluorochloridone) applied at a dose of 3.0 dm<sup>3</sup> ha<sup>-1</sup> up to 10 days after planting of potato tubers; 4) combined mechanical and chemical weed control, including ridging and harrowing and twice ridging before potato emergence and treatment with herbicide Sencor 70 WG (metribuzin), dosed 1.0 kg ha<sup>-1</sup>, immediately before the potato emergence. The work was aimed to determine the effect of herbicides on the content of dry matter, total sugars and reducing sugars in the potato edible tubers. Herbicides application at potato cultivation, as compared to mechanical cultivation (as control variant), contributed to the increase total sugars and reducing sugars. The highest macronutrients content was determined in the tubers of potato sprayed with Plateen 41.5 WG and Racer 250 EC. The concentration of dry matter and reducing sugars in potato tubers was significantly affected by the cultivars and weather conditions during the growing season. Weed control chemicals increasing an accumulation of total sugars and reducing sugars may lead to excluding potato from processing into chips and crisps.

**Key words:** *Solanum tuberosum*, dry matter, total sugars, reducing sugars, suitability for processing.

### INTRODUCTION

Potato is one of major crop plants in the world, Europe and Poland, and is a staple food in human nutrition (Gomul et al., 2011; Abolgasem, 2014; Wegener et al., 2015). Potato consumption in Poland is quite high and has reached the level of 107-130 kg per person. Over the season 2013/2014, per capita consumption in Poland was 102 kg, it being higher in Lativa only (Dzwonkowski et al., 2014). Potato nutritional value is affected by tuber chemical composition, in particular dry matter, total sugars, reducing sugars, protein, vitamins, minerals and harmful substances (Kolasa, 1993; Leszczyński, 2012; Wójcik-Stopczyńska et al., 2012; Sawicka et al.,

2015). Special attention should be paid to sugars which influence tuber quality of potato for direct consumption, drying, canning and frying. During frying, reducing sugars react with free amino acids, which leads to formation of dark brown-coloured compounds and harmful acrylamide (Zgórska and Grudzińska, 2012; Krzysztofik, 2013). Tuber chemical components are affected by cultivar but also by agrotechnological operations and environmental conditions (Jarych, 2004; Wojdyła et al., 2009; Zarzecka and Gugala, 2009; Abolgasem, 2014; Grudzińska et al., 2014). As it has been speculated that herbicides may affect the chemical composition of plants, studies are undertaken to examine the effect of plant protection

chemicals on the nutritional value of the produce (Rola and Kieloch, 2001; Sawicka and Pszczółkowski, 2005; Gugala and Zarzecka, 2013). Hence, the objective of this work was to determine the effect of herbicides on dry matter, total sugars and reducing sugars in table potato tubers.

## MATERIAL AND METHODS

Results of a three-year study conducted at the Zawady Experimental Farm (52°03'N; 22°33'E) were used. The field experiment was performed on sandy soil, with pH being slightly acidic and acidic. The soil was characterized by the mean to very high content of phosphorus and potassium, medium concentration magnesium (Table 1).

A two-factor field experiment was designed as a split-plot arrangement of plots with two potato cultivars (Irga and Balbina) as factor 1 and four weed control methods (1. mechanical weed control prior to and after potato plant emergence – control; 2. mechanical and chemical weed control: hilling and harrowing followed by two hillings, then spraying with Plateen 41.5 WG (metribuzin + flufenacet) at a rate of 2.0 kg ha<sup>-1</sup> just before emergence; 3. mechanical and chemical weed control: one hilling and spraying with Racer 250 EC (fluorochloridone) at a rate of 3.0 dm<sup>3</sup> ha<sup>-1</sup> during 10 days after planting, 4. mechanical and chemical weed

control: hilling and harrowing followed by two hillings and spraying with Sencor 70 WG (metribuzin) at a rate of 2.0 kg ha<sup>-1</sup> prior to emergence) as factor 2.

Table 1. Chemical properties of the soil in experiment

Years	pH 1 mol KCl <sup>-3</sup>	Macroelements content (mg kg <sup>-1</sup> )			
		N total	P	K	Mg
2008	5.74	0.90	45.0	85.6	45.1
2009	4.90	0.64	55.4	159.4	39.0
2010	5.50	0.80	99.4	149.4	50.0

Potato followed winter triticale and was fertilised with farmyard manure (25 t ha<sup>-1</sup>) and mineral fertilisers (N: 90.0, P: 39.6, K: 112.0 kg ha<sup>-1</sup>). Prior to harvest, in all the plots tubers of 10 plants were randomly dug up and chemical analyses were conducted in samples of edible tubers. Dry matter was determined gravimetrically. Total sugars and reducing sugars were determined in the fresh matter of tubers by the Schoorl-Luff method (Krelowska-Kulas, 1993). The results were statistically analysed by variance analysis. Significance of sources of variation was checked by the F Fisher-Snedecor test and the significance of differences between means was checked at p=0.05 using the Tukey confidence intervals. Weather conditions in the study years varied (Table 2).

Table 2. Weather conditions in potato vegetation period in the years 2008-2010

Years	Months						
	IV	V	VI	VII	VIII	IX	IV-IX
Rainfalls (mm)							
2008	28.2	85.6	49.0	69.8	75.4	63.4	371.4
2009	8.1	68.9	145.2	26.4	80.9	24.9	354.4
2010	10.7	93.2	62.6	77.0	106.3	109.9	459.7
Mean for multiyear 1987-2000	38.6	44.1	52.4	48.9	43.0	47.3	275.2
Air temperature (°C)							
2008	9.1	12.7	17.4	18.4	18.5	12.2	14.7
2009	10.3	12.9	15.7	19.4	17.7	14.6	15.1
2010	8.9	14.0	17.4	21.6	19.8	11.8	15.6
Mean for multiyear 1987-2000	7.8	12.5	17.2	19.2	18.5	13.1	14.7

In the 2008 growing season, precipitation was more compared with the long-term mean and unevenly distributed during the yield

accumulation months (July, August). In turn, temperatures were higher compared with the years 1987-2000.

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The growing season 2009 was the most favourable of all the study years. In 2010, which was the warmest of all the study years, precipitation was high and varied during the growing season.

## RESULTS AND DISCUSSION

In table potato production, dry matter content and total sugars content (glucose + fructose + saccharose) are two of major traits determining suitability of tubers for direct consumption as well as processing for diced potatoes, salad and pasteurised products. Tubers should contain 18-22% dry matter and up to 1% total sugars because when this level is exceeded potatoes taste sweet (Lisińska, 2006; Zgórska and Grudzińska, 2012). The study results revealed significant differences between cultivars in terms of dry matter content (Table 3).

Table 3. Content of dry matter, total sugars and reducing sugars in potato tubers (%)

Weed control methods	Cultivars		Mean
	Irga	Balbina	
Dry matter (%)			
1. Control object	19.20	20.22	19.71
2. Plateen 41.5 WG	19.10	20.05	19.58
3. Racer 250 EC	18.98	20.02	19.50
4. Sencor 70 WG	19.18	20.18	19.68
Mean	19.12	20.12	19.62
LSD <sub>0.05</sub> : Cultivars			0.27
Weed control methods			n.s.
Cultivars x weed control methods			n.s.
Total sugars (%)			
1. Control object	0.642	0.664	0.652
2. Plateen 41,5 WG	0.644	0.671	0.658
3. Racer 250 EC	0.646	0.674	0.660
4. Sencor 70 WG	0.646	0.664	0.655
Mean	0.645	0.668	0.656
LSD <sub>0.05</sub> : Cultivars			0.004
Weed control methods			0.005
Cultivars x weed control methods			n.s.
Reducing sugars (%)			
1. Control object	0.342	0.358	0.351
2. Plateen 41,5 WG	0.354	0.360	0.357
3. Racer 250 EC	0.344	0.361	0.353
4. Sencor 70 WG	0.344	0.361	0.353
Średnio – Mean	0.346	0.360	0.354
LSD <sub>0.05</sub> : Cultivars			0.004
Weed control methods			0.005
Cultivars x weed control methods			0.005

n.s. - non significant differences.

Balbina contained more dry matter (by 1.0%) than Irga, which has also been confirmed by other authors (Jarych, 2004; Abbas et al., 2011; Wójcik-Stopczyńska et al., 2012; Kaur and Aggarwal, 2014).

Dry matter was not affected by weed control methods including herbicide application, but it was influenced by weather conditions over the study years (Table 4). Significantly more dry matter was accumulated by tubers in 2009, which was warm, compared with the remaining years, the finding was confirmed in other studies (Sawicka and Pszczółkowski, 2005; Boguszevska, 2007).

Table 4. Content of dry matter, total sugars and reducing sugars in potato tubers depending on cultivars and weather conditions

Years	Cultivars		Mean
	Irga	Balbina	
Drymatter (%)			
2008	19.05	19.58	19.32
2009	19.97	20.25	20.11
2010	18.32	20.52	19.42
Mean	19.12	20.12	19.62
LSD <sub>0.05</sub> : Years			0.42
Cultivars			0.27
Years x cultivars			0.48
Total sugars (%)			
2008	0.644	0.665	0.655
2009	0.647	0.678	0.663
2010	0.643	0.660	0.652
Mean	0.645	0.668	0.656
LSD <sub>0.05</sub> : Years			n.s.
Cultivars			0.004
Years x cultivars			n.s.
Reducing sugars (%)			
2008	0.352	0.360	0.356
2009	0.325	0.353	0.339
2010	0.363	0.367	0.365
Mean	0.346	0.360	0.354
LSD <sub>0.05</sub> : Years			0.006
Cultivars			0.004
Years x cultivars			0.007

n.s. – non significant differences.

Statistical analysis demonstrated that total sugars depended on the cultivar and weed control method (Tables 2 and 3). It averaged 0.656%, so it was less than 1%, which is favourable from the consumers' point of view. Cultivar Balbina contained more total sugars than Irga, which agrees with results reported by other authors (Jarych, 2004; Wojdyła et al.,

2009; Bhattacharjee et al., 2014) who found that the trait was affected by genotype. By contrast, Gugala and Zarzecka (2013) did not observe changes in the concentration of total sugars in the cultivars they grew. The herbicides Plateen 41.5 WG and Racer 250 EC applied to control weeds in potato increased total sugars compared with control tubers. Sawicka and Pszczółkowski (2005) observed a tendency for total sugars to increase after an application of herbicides, whereas Kraska (2002) demonstrated that total sugars increased following increased fertilisation and an application of plant protection chemicals.

Long-term studies (Lisińska, 2006; Zgórska and Grudzińska, 2012; Krzysztofik, 2013; Grudzińska et al., 2014) have demonstrated that potatoes for direct consumption as well as for processing into dried and tinned products should contain up to 0.5%, chips 0.25-0.5%, and crisps 0.15-0.25% reducing sugars. In the study reported here, reducing sugars were affected by cultivar, weed control methods and study years, and averaged 0.354% (Tables 2 and 3). Balbina accumulated more reducing sugars than Irga. The herbicide Plateen 41.5 WG increased the accumulation of reducing sugars, whereas the remaining chemicals did not significantly affect this characteristic. Moreover, it was observed that in 2009 the concentrating of reducing sugars was the lowest compared with the remaining study years. A similar response to herbicide application and weather conditions was reported by other authors (Sawicka and Pszczółkowski, 2005; Boguszevska, 2007; Gugala and Zarzecka, 2013).

## CONCLUSIONS

Of the cultivars grown in this experiment, Balbina contained more dry matter, total sugars and reducing sugars than Irga.

The herbicides applied to control weeds in potato increased total sugars (Plateen 41.5 WG and Racer 250 EC) and reducing sugars (Plateen 41.5 WG) compared with control tubers.

Weed control chemicals increasing an accumulation of total sugars and reducing

sugars may lead to excluding potato from processing into chips and crisps.

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