INTRODUCTION

Potato is an important staple food in Poland as in many other countries [Camire et al. 2009, Horvat et al. 2014, Leszczyński 2012, Ezekiel et al. 2013, Wegener et al. 2015]. The annual average per capita consumption of potatoes in Poland over the past few years is about 112-130 kg per year [Dzwonkowski et al. 2012]. The quality of potato tubers depends on chemical composition, which can significantly affect the nutrient availability of the potato. Potato tubers contain nutritional components and also anti-nutritional ingredients such as nitrates, glycoalkaloids, heavy metals and pesticides [Kolasa 1993, Rembialkowska, Średnicka 2009, Wierzbicka 2011]. The smallest possible content of these toxins in potato tubers is required.

EFFECT OF SOME HERBICIDES APPLICATION ON NITRATES (V) CONTENT IN POTATO TUBERS

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ABSTRACT

A field experiment was carried out in the Agricultural Experimental Station Zawady (52°03’ N; 22°33’E), owned by the Siedlce University of Natural Sciences and Humanities in 2005–2007. The research was designed as a two factors randomized block with three replicates. The factors examined in the experiment included two potato varieties – Irga and Balbina and four weed control methods combined mechanical and chemical for herbicides application: Plateen 41,5 WG (metribuzin + flufenacet), Racer 250 EC (fluorochloridone), Sencor 70 WG (metribuzin), and control object – mechanical weeding before and after potato sprouting. The study was designed to test the influence of weed control methods on nitrates content in consumption potato tubers. The nitrates (V) content depended on the weed control methods, varieties and weather conditions throughout the growing season. The highest nitrates (V) content was determined when weeds were controlled mechanically and chemically using Sencor 70 WG. The study results demonstrated that Balbina had a higher concentration of nitrates (V) compared with Irga.

Keywords: herbicides, nitrates (V), potato tubers, varieties
2000, Lachman et al. 2005, Gugała, Zarzecka 2009], agronomical factors which primarily are: fertilization, tillage, protection against agrophages [Frydecka-Mazurczyk, Zgórska 1996, Lachman et al. 2005, Zarzecka et al. 2010, Wierzbicka 2011], environmental conditions [Rogozińska et al., 2005, Grudzińska, Zgórska 2008, Bensa et al. 2012]. The aim of this study was to determine the impact of the reducing weeds herbicides on nitrates (V) content in the tubers of two potato varieties.

MATERIALS AND METHODS

The results of the study derive from the field experiment carried in the Agricultural Experimental Station Zawady (52°03’ N; 22°33’ E), owned by the Siedlce University of Natural Sciences and Humanities in Poland. The field experiment was performed in the years 2005–2007 on sandy soil, IVa class, with pH being slightly acidic and acidic. The soil was characterized by the mean to very high content of phosphorus and potassium, moreover by the magnesium content ranging from high to very high (Table 1). The research was designed in a split-plot system in three replications, including two different factors. Factor I included two edible potato varieties: Irga and Balbina, and factor II: four methods of weed control:

1) mechanical weed control in the period prior to potato emergence and after potato emergence – control object,
2) combined mechanical and chemical weed control, including ridging and harrowing and ridging and treatment with herbicide Plateen 41,4 WG (metribuzin + flufenacet) at a dose of 2.0 kg·ha⁻¹ immediately before the emergence of potato plants,
3) combined mechanical and chemical weed control, comprising single ridging and treatment with herbicide Racer 250 EC (fluorochlordone) applied at a dose of 3.0 l·ha⁻¹ up to 10 days after planting potato tubers,
4) combined mechanical and chemical weed control, including ridging and harrowing and ridging, and treatment with herbicide Sencor 70 WG (metribuzin), dosed 1.0 kg·ha⁻¹, immediately before the potato emergence.

Potato was cultivated in the field after winter triticale. In autumn the farmyard manure in amount of 25.0 t·ha⁻¹ as an organic fertilizer, and mineral fertilizations were applied at the respective rates of 39.6 kg P (in the form of 46% triple superphosphate), 112.1 kg K (in the form of 60% potassium salt) per 1 ha. In springtime before planting time, the nitrogen fertilizers were applied in the dose N-90 kg·ha⁻¹ (in the form of 34% ammonium salt peter). Potatoes were planted in the third decade of April and were harvested at proper stage of maturity in the third decade of September and in the first decade of October. Nitrates (V) content was determined with ionoselective nitrate electrode and chlorinesilver reference electrode [Kolbe, Müller 1987]. The results were subjected to the statistical analysis with the method of the analysis of variance. Significance of variability sources was tested with the Fisher-Snedecor ‘F’ test, and rating significance of differences at P = 0.05 between the compared means using Tuke’y test.

The weather conditions in the years of the research period was varied (Table 2). In growing season in 2005 the rainfall was lower by 74.5 mm than in multiyear period. June 2006 was less wet with higher air temperature, moreover during the growing season, rainfalls were unevenly distributed, air temperatures were higher than in multi-year period 1981–1995. In 2007 the rainfall was the most abundant additionally it was the warmest year. In 2007 the growing season was characterized by the most favorable climate conditions – rainfalls were evenly distributed and air temperatures were virtually the same as in the multiyear period.

RESULTS AND DISCUSSION

The research studies gave result of 110.68 mg kg⁻¹ of nitrates (V) content in fresh matter of potato tubers, which was close to the data obtained by other authors [Frydecka-Mazurczyk, Zgórska 2000, Lachman et al. 2005, Zarzecka et al. 2010, Abbasi et al. 2011], furthermore the amount was twice lower than permitted by the Directive [Directive 2005].

Herbicides used in the research for weed control (Plateen 41.5 WG, Racer 250 EC, Sencor 70 WG) significantly increased the concentration of nitrates (V) in potato tubers in comparison with control object (Table 3). Hamouz et al. [2005], Lachman et al. [2005] observed an increased nitrates content in tubers in the conventional tillage method with herbicides application comparing with the tubers of the eco-
logical tillage method. Although the differences were not statistically confirmed. Zarzecka et al. [2010] also did not show the influence of herbicides on nitrates (V) content in tubers, but they reported a tendency to increase. Chemical weed control allows to obtain high yields of the desired quality, and pesticides used at optimal doses and terms should not affect the health of the consumer or biological quality of the plants and the soil [Baćmaga et al. 2007].

The conducted studies revealed different nitrates (V) amounts in tubers of potato varieties. Significantly higher amount was accumulated by Balbina variety than Irga. The differences between cultivars in respect to nitrate accumulation are indicated in studies of many authors [Frydecka-Mazurczyk, Zgórska, 2000, Lachman et al. 2005, Gugała, Zarzecka 2009, Marks 2009]. Frydecka-Mazurczyk, Zgórska [1996] and Wierzbicka [2011] demonstrate that main crop and late main crop have lower nitrates accumulation than early varieties.

The tubers harvested in individual years of this research differed in nitrates (V) content (Table 3, 4). Comparing to previous years, the highest amount of nitrates was accumulated in potato tubers in 2006, the warmest and exceptionally wet year. Furthermore, it was characterized by unevenly distributed rainfall over the months of growing time. Nevertheless the smallest amount of these compounds was found in potato tubers harvested in 2007 with evenly distributed rainfall, whereas temperature was pretty near the average sum for the multiyear period. As

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<th>Table 1. Chemical properties of the soil in experiment</th>
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<th>Table 2. Weather conditions in potato growing season in the years 2005–2007</th>
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| Mean sum in multiyear (1981-1995) | 52,3 | 50,0 | 68,2 | 45,7 | 66,8 | 60,7 | 343,7 |

| Mean for multiyear (1981-1995) | 7,7 | 10,0 | 16,1 | 19,3 | 18,0 | 13,0 | 14,0 |

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<th>Table 3. Content of nitrates (V) in potato tubers (mg kg⁻¹ fresh matter)</th>
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<td><strong>Weed control methods</strong></td>
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<td>1. Control object</td>
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<td>2. Plateen 41,5 WG</td>
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<td>3. Racer 250 EC</td>
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<td>4. Sencor 70 WG</td>
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| Mean | 103.66 | 117.72 | 110.21 | 116.31 | 105.55 | 110.68 | 0.42, varieties = 0.27, weed control methods = 0.36 interaction: weed control methods x years = n.s. n.s. – no significant difference |
stated by: Frydecka-Mazurczyk, Zgórska [2000],
Gugała, Zarzecka [2009] the least content of ni-
trates in tubers was determined by the average air
temperature (16–18 °C) and optimal total rainfall
during the growing season. Grudzińska, Zgórska
[2008] and Pobereżny [2008] were observing
increase of nitrates level during severe weather
conditions in growing season (low or high level
of rainfall, either too high temperature or tempo-
rary rain shortage).

The nitrates (V) found in the tubers do not pose a threat to human health if the potato
is grown in optimal wheather and soil condi-
tions, and agricultural practices are carried out
properly and in accordance with the direction
of use. Although, the occurrence of these com-
ounds is reduced approximately 35–36% by
peeling potatoes for traditional potato consump-
tion [Golaszewska, Zalewski 2001, Zarzecka et
al. 2010]. Mozolewski and Smoczyński 2004]
showed that after preliminary process (washing,
manual peeling and rinsing) that nitrates amount
was reduced from 25.5 to 75.3% and it depended
on potato variety.

CONCLUSIONS

The study results have demonstrated that
nitrates (V) content depended on the weed con-
trol methods, varieties and weather conditions
throughout the growing season. The highest ni-
trates (V) content was determined when weeds
were controlled mechanically and chemically us-
ing herbicide Sencor 70 WG. The variety Balbina
had a higher concentration of nitrates (V), on av-
erage 117.72 mg·kg⁻¹ fresh matter, compared with
Irga – 103.66 mg·kg⁻¹. The highest concentration
of nitrates (V) in potato tubers was obtained in
2006, which was warmest and exceptionally wet
year for potato growth.

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