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*Research Article*

# THE EFFECT OF AGROTECHNICAL FACTORS ON THE POTASSIUM CONTENT AND ITS REMOVAL BY POTATO TUBERS

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**ABSTRACT**

A 3-year field experiment covered two methods of soil tillage, conventional and simplified, as well as the following herbicide options: Plateen 41,5 WG, Plateen 41,5 WG + Fusilade Forte 150 EC, Plateen 41,5 WG + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC, Barox 460 SL, Barox 460 SL + Fusilade Forte 150 EC, Barox 460 SL + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC and control object – mechanical weeding. Potassium content and its removal by potato tubers significantly depended on soil tillage methods, weed control methods and research years. More potassium was contained in tubers harvested from conventional tillage compared with the reduced tillage. Herbicides applied in the potato field significantly decreased potassium content in tubers compared with the control object. Simplifications of soil tillage decreased potassium accumulation in potato tubers compared with the conventional tillage. Significant changes were also observed in content of potassium and its removal by 1 tonne tubers between the experimental years.

**Keywords**: potato, herbicides, potassium, tillage systems.

## INTRODUCTION

Potato (*Solanum tuberosum* L.) as a staple food in many countries [Eremeev et al. 2008, Ezekiel et al. 2013, Wegener et al. 2015] is an important crop in Poland [Leszczyński 2012]. Potato tubers contain about 1% mineral compounds, mainly potassium, in fresh mass [Kabata-Pendias 2001, Kolasa 1993, Zarzecka et al. 2015]. Consumption of 200 g of potatoes covering 30% of the daily needs [Leszczyński 2012], and consumption of about 300 g of tubers should cover in 48% to this element [Wichrowska et al. 2009]. Potassium plays an important physiological and building material role. Potassium regularizes the supply management in water of plant, activates over 60 different enzymatic reactions, stimulates the process of simple sugars, complex sugars, fats and organic acids syntheses [Rivero et al. 2003]. The content of potassium in potato tubers may change as an effect of cultivar properties [Miles, Buchman 2009, Zarzecka, Gugała 2004], weather conditions during vegetation [Tekalign, Hammes 2005, Wadas et al. 2008], and also by agricultural measure applied, including plant protection against weed infestation [Klikocka 2001, Wichrowska et al. 2009]. According to the literature on the subject, the effect of herbicides on the mineral composition of potato tubers is not wholly explicit. Thus the objective of the present work has been to determine the effect of various treatments of cultivation and herbicides and their mixtures on the potassium content and its removal by edible potato tubers.

## MATERIAL AND METHODS

A study was carried out cv. Wiking obtained from a field experiment conducted in 2009–2011 in Agricultural Experimental Station owned by the Siedlce University of Natural Sciences and

Humanities. The soil originating from light clay sands belonging to the very good rye complex. The experiment was set up with the method of randomized sub-blocks, in three replications. The first experimental factors were two soil tillage systems – traditional (ploughing + fall ploughing + harrowing + cultivating + harrowing) and simplified (reversing ploughing + cultivating). The second experimental factors were seven methods of weed control including herbicides and their mixtures:

- control object – mechanical weeding before and after potato sprouting,
- Plateen 41,5 WG (metribuzin + flufenacet) 2.0 kg ha$^{-1}$,
- Plateen 41,5 WG (metribuzin + flufenacet) 2.0 kg ha$^{-1}$ + Fusilade Forte 150 EC (fluazyfop-P-butyl) 2.5 dm$^3$ ha$^{-1}$ (mixture),
- Plateen 41,5 WG (metribuzin + flufenacet) 1.6 kg ha$^{-1}$ + Fusilade Forte 150 EC (fluazyfop-P-butyl) 2.0 dm$^3$ ha$^{-1}$ + adjuvant Atpolan 80 EC 1.5 dm$^3$ ha$^{-1}$ (mixture),
- Barox 460 SL (bentazone + MCPA) 3.0 dm$^3$ ha$^{-1}$,
- Barox 460 SL (bentazone + MCPA) 3.0 dm$^3$ ha$^{-1}$ + Fusilade Forte 150 EC (fluazyfop-P-butyl) 2.5 dm$^3$ ha$^{-1}$ (mixture),
- Barox 460 SL(bentazone + MCPA) 2.4 dm$^3$ ha$^{-1}$ + Fusilade Forte 150 EC(fluazyfop-P-butyl) 2.0 dm$^3$ ha$^{-1}$+ adjuvantAtpolan 80 EC 1.5 dm$^3$ ha$^{-1}$ (mixture).

The mechanical treatment was applied on the referential experimental cultures 2 to 7 until the plant germination. Herbicides and their mixtures were applied just before the germination of potato (treatments 2-4) and after potato germination (germination 5-7). Farmyard manure (25 t ha$^{-1}$) and mineral fertilization in the amounts of: 90 kg N, 32.9 kg P and 112.1 kg K per hectare ware applied on a regular basic. The area of one plot was 25 m$^2$. Potato were planted manual in the spacing of 76.5×37 cm. Potato were harvested in the first decade of September in technological maturity phase. Potassium content was determined in tuber dry matter following wet mineralization of the plant by atomic absorption spectrophotometry (AAS) method. Potassium removal by tuber yield was calculated from the product of tuber dry matter yield and potassium content. The results were evaluated statistically using the variance analysis according to the design of the experiment. The smallest significant difference was calculated with the use of Tukey's test.

Weather conditions over the period of experiments are presented in Table 1. The year 2009 was a warm with a quite favourable distribution of temperatures and different rainfall rates, with total rainfall lower than the long-term means. In all growing months the 2010, rainfall deficiency was observed compared to the long-term period and the highest rainfall deficiency occurred in June, July and August. When analysis the pattern of weather conditions in 2011, it was found out that year was wet, but rainfall was distributed unevenly throughout particular growing months. Mean rainfall and mean temperature in the period in question was similar to the long-term mean.

## RESULTS AND DISCUSSION

The average potassium content in potato tuber dry matter was 26.98 g kg$^{-1}$, which ranged from 24.22 to 31.35 g kg$^{-1}$ (Table 2). Potassium content in tubers was similar to the levels reported by other authors [Barczak, Nowak 2014, Boligłowa, Dzienia 1999, Burrowes, Ramer 2008, Yildrim, Tokusoğlu 2005]. In the present study, higher potassium concentration was found in tubers of conventionally tilled potatoes,

**Table 1.** Air temperatures and rainfall in the vegetation period of potato in 2009–2011

| Months | Air temperature (°C) | | | | Rainfall (mm) | | | |
|---|---|---|---|---|---|---|---|---|
| | mean of many years | mean of month | | | mean of many years | mean of month | | |
| | 1981–1995 | 2009 | 2010 | 2011 | 1981–1995 | 2009 | 2010 | 2011 |
| IV | 7.7 | 9.0 | 7.1 | 8.0 | 52.3 | 12.9 | 13.6 | 35.9 |
| V | 10.0 | 17.0 | 15.6 | 11.6 | 50.0 | 51.3 | 37.2 | 97.0 |
| VI | 16.1 | 17.2 | 18.4 | 15.4 | 68.2 | 61.1 | 26.6 | 52.8 |
| VII | 19.3 | 21.0 | 20.0 | 17.5 | 45.7 | 99.6 | 26.1 | 49.0 |
| VIII | 18.0 | 20.2 | 18.5 | 18.9 | 66.8 | 66.5 | 4.7 | 66.7 |
| IX | 13.0 | 12.9 | 13.5 | 13.0 | 60.7 | 18.7 | 24.3 | 19.5 |
| IV–IX | mean 14.0 | 16.2 | 15.5 | 14.1 | sum 343.7 | 310.1 | 132.5 | 320.9 |

compared with the simplified tillage. Increased potassium concentration in tubers was also observed by Klikocka [2001], who applied the conventional tilled. Westerman and Sojka [1996] proved that deeper tillage prior to the cultivation of root and tuber crops positively influenced yields of basic plants, as well as the content and removal of mineral compounds.

The potassium concentration in potato tubers after herbicides treatment was significantly lower by 5.3% in tubers in relation to content tubers from the control objects. Similar changes were observed by Klikocka [2001]. Zarzecka and Gugała [2004] noted a tendency of decreasing the content of potassium in tubers under such conditions, while Wichrowska et al. [2009] noticed a tendency of increasing concentration this macroelement after applied herbicides. Moreover, concentration of potassium were significantly differentiated by weather conditions over the study years. The highest amount of potassium was in the tubers harvested in the warm and dry 2010. The influence of weather conditions on potassium content was proven in many scientific works [Barczak, Nowak 2014, Mazurczyk, Lis 2001, Wadas et al. 2008, Gugała, Zarzecka

**Table 2.** Content of potassium in the dry matter in potato tubers (g kg$^{-1}$)

| Weed control methods | Tillage systems | | Years | | | Mean |
|---|---|---|---|---|---|---|
| | traditional | simplified | 2009 | 2010 | 2011 | |
| 1. Control object | 28.52 | 27.99 | 28.68 | 31.35 | 24.73 | 28.25 |
| 2. Plateen 41.5 WG | 27.08 | 26.69 | 27.80 | 28.31 | 24.54 | 26.88 |
| 3. Plateen 41.5 WG + Fusilade Forte 150 EC | 26.76 | 26.51 | 27.34 | 28.28 | 24.30 | 26.64 |
| 4. Plateen 41,5 WG + Fusilade Forte 150 EC+Atpolan 80EC | 27.35 | 26.89 | 28.13 | 28.58 | 24.66 | 27.12 |
| 5. Barox 460 SL | 26.92 | 26.47 | 27.44 | 28.31 | 24.34 | 26.70 |
| 6. Barox 460 SL + Fusilade Forte 150 EC | 26.51 | 26.34 | 26.79 | 28.27 | 24.22 | 26.43 |
| 7. Barox 460 SL + Fusilade Forte 150 EC+Atpolan 80EC | 26.97 | 26.67 | 27.69 | 28.30 | 24.47 | 26.82 |
| Mean | 27.15 | 26.80 | 27.70 | 28.77 | 24.46 | 26.98 |
| $LSD_{0.05}$ for: | | | | | | |
| • tillage systems | | | | | | 0.02 |
| • weed control methods | | | | | | 0.15 |
| • years | | | | | | 0.03 |
| Interaction: | | | | | | |
| • tillage systems × year | | | | | | 0.04 |
| • weed control methods × years | | | | | | 0.27 |

**Table 3.** Uptake of potassium by potato tubers (kg per 1 tonne)

| Weed control methods | Tillage systems | | Years | | | Mean |
|---|---|---|---|---|---|---|
| | traditional | simplified | 2009 | 2010 | 2011 | |
| 1. Control object | 7.52 | 7.56 | 7.74 | 8.79 | 6.08 | 7.54 |
| 2. Plateen 41,5 WG | 6.92 | 7.05 | 7.18 | 7.86 | 5.93 | 6.99 |
| 3. Plateen 41,5 WG + Fusilade Forte 150 EC | 6.79 | 6.89 | 6.88 | 7.83 | 5.81 | 6.84 |
| 4. Plateen 41,5 WG + Fusilade Forte 150 EC+Atpolan 80EC | 7.10 | 7.15 | 7.45 | 7.93 | 6.02 | 7.13 |
| 5. Barox 460 SL | 6.95 | 6.98 | 7.14 | 7.82 | 5.93 | 6.97 |
| 6. Barox 460 SL + Fusilade Forte 150 EC | 6.80 | 6.87 | 6.87 | 7.78 | 5.88 | 6.84 |
| 7. Barox 460 SL + Fusilade Forte 150 EC+Atpolan 80EC | 7.01 | 7.14 | 7.44 | 7.84 | 5.96 | 7.08 |
| Mean | 7.01 | 7.09 | 7.24 | 7.98 | 5.94 | 7.05 |
| $LSD_{0.05}$ for: | | | | | | |
| • tillage systems | | | | | | 0.03 |
| • weed control methods | | | | | | 0.11 |
| • years | | | | | | 0.04 |
| Interaction: | | | | | | |
| • tillage systems x years | | | | | | 0.05 |
| • weed control methods x years | | | | | | 0.21 |

2011]. Klikocka [2001] claimed that during a few moist year, potassium was more for about 2% (a relative results) than in the wet year. The experiment revealed that there is an interaction between weed control methods and the years and tillage systems and years. The higher potassium concentration was in the tubers in conditions rainfall deficiency (2003), and in 2011 it was the lowest when air temperature and rainfall conditions were similar to the long-term mean.

Potassium removal by potato tubers was influenced by cultivation operations performed in the experiment (soil tillage systems and weed control methods) and moisture and thermal conditions in the study (Table 3). Conventionally-tilled potatoes took up 1.0% less potassium than the potatoes whose cultivation was based on simplified tillage. Significantly increased removal of potassium occurred in the tubers with the mechanical weeding control than herbicides and their mixtures application. Higher potassium removal by 1 tonne tubers was mainly associated with higher potato content this macroelement in tubers from the plots where weeds were mechanically controlled. Under conditions of the experiment potassium removal was similar to the data cited by Grześkiewicz and Mazurczyk [2001].

## CONCLUSIONS

Simplifications of soil tillage decreased potassium accumulation and increased removal by 1 tonne of potato tubers compared with the conventional tillage. The potassium content in potato tubers was decreased by herbicides and their mixtures in comparison with mechanical weeding.

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