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EFFECT OF INSECTICIDES ON PHOSPHORUS AND POTASSIUM CONTENT IN TUBERS OF THREE POTATO CULTIVARS

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Abstract

Potato tubers were examined in a field experiment conducted over the years 2004--2006 and arranged as a split-plot design with three replicates. Two factors were studied: I – three mid-early cultivars of edible potato: Wiking, Mors, Żagiel; II – six methods of Colorado beetle control: control (without application of chemicals), Actara 25 WG (0.08 kg ha^{-1}), Regent 200 SC (0.1 dm^3 ha^{-1}), Calypso 480 SC (0.05 dm^3 ha^{-1}), Calypso 480 SC (0.075 dm^3 ha^{-1}) and Calypso 480 SC (0.1 dm^3 ha^{-1}). Potassium content was determined in the dry matter of potato tubers following wet mineralization and using atomic absorption spectrophotometry (AAS). Phosphorus was determined by means of the photometric method. The objective of the study was to examine the effect of insecticides used to control Colorado beetle on phosphorus and potassium content in potato tubers. Most potassium was found in the tubers of Mors – 27.19 g kg^{-1} on average, significantly less in Wiking – 25.14 g kg^{-1} on average, and the least in Żagiel –23.67 g kg^{-1} on average. The highest and lowest phosphorus concentrations were determined in, respectively, Mars (3.490 g kg^{-1} on average) and Wiking (2.910 g kg^{-1} on average). Application of insecticides resulted in a significant increase in potassium and phosphorus content in tubers, which ranged from an average of 0.15 to 0.61 g kg^{-1} for potassium and 0.059 to 0.118 g kg^{-1} for phosphorus, compared with the control. Our analysis of the influence of atmospheric conditions on phosphorus content in potato tubers demonstrated that the highest phosphorus levels, 3.563 g kg^{-1} on average, were determined in 2006, which was characterized by the highest precipitation and temperature. The lowest potassium accumulation in potato tubers was recorded in 2004, 2.897 g kg^{-1} on average.

Key words: insecticides, cultivars, phosphorus, potassium.

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WPŁYW INSEKTYCYDÓW NA ZAWARTOŚCI FOSFORU I POTASU W BULWACH TRZECH ODMIAN ZIEMNIAKA

Abstrakt

Materiał badawczy stanowiły bulwy ziemniaka pochodzące z doświadczenia polowego przeprowadzonego w latach 2004-2006 założonego metodą losowanych podbloków (split-plot) w trzech powtórzeniach. Badano w nim dwa czynniki: I – trzy średnio wczesne odmiany ziemniaka jadalnego: Wiking, Mors, Żagiel, II – sześć sposobów zwalczania stonki ziemniaczanej: 1) obiekt kontrolny – bez ochrony chemicznej, 2) Actara 25 WG (0,08 kg ha^{-1}), 3) Regent 200 SC (0,1 dm^3 ha^{-1}), 4) Calypso 480 SC (0,05 dm^3 ha^{-1}), 5) Calypso 480 SC (0,075 dm^3 ha^{-1}), 6) Calypso 480 SC (0,1 dm^3 ha^{-1}). Zawartość potasu oznaczono w suchej masie bulw ziemniaka po mokrej mineralizacji, metodą absorpcyjnej spektrofotometrii atomowej (ASA). Fosfor oznaczono metodą fotometryczną. Celem badań było określenie wpływu insektycydów do zwalczania stonki ziemniaczanej na zawartość fosforu i potasu w bulwach ziemniaka. Najwięcej potasu zawierały bulwy odmiany Mors – średnio 27,19 g kg^{-1}, istotnie mniej Wiking – średnio 25,14 g kg^{-1}, a najmniej odmiana Żagiel – średnio 23,67 g kg^{-1}. Natomiast najwięcej fosforu zawierała odmiana Mors – średnio 3,490 g kg^{-1}, a najmniej Wiking – średnio 2,910 g kg^{-1}. W wyniku stosowania insektycydów odnotowano istotne zwiększenie ilości potasu w bulwach w porównaniu z obiektem kontrolnym – średnio od 0,15 do 0,61 g kg^{-1} oraz zawartości fosforu – średnio od 0,059 do 0,118 g kg^{-1}. Analizując wpływ warunków atmosferycznych na zawartość fosforu w bulwach ziemniaka, stwierdzono, że najwięcej zawierały go ziemniaki uprawiane w 2006 r. – średnio 3,563 g kg^{-1}, w którym zanotowano najwyższe opady i temperatury. Najmniej tego pierwiastka bulwy kumulowały w 2004 r. – średnio 2,897 g kg^{-1}.

Słowa kluczowe: insektycydy, odmiany, fosfor, potas.

INTRODUCTION

Potatoes are a very popular crop plant in Poland and their consumption remains high. As the mineral content of potato tubers is approximately 1%, they may be a significant source of nutrients and essential elements for the human body, although they can also contain harmful elements (SZTEKE et. al. 2006).

Studies by WICHROWSKA et al. (2009) have indicated that consumption of about 300 g potatoes provides the body with 48.6% of potassium and 25.1% of phosphorus.

The mineral content of potato tubers is predominantly influenced by the genotype and weather conditions. Moreover, it can also be affected by agrotechnological practices, fertilization, soil tillage and plant protection agents in particular (CZEKAŁA, GŁADYSIAK 1995, KRASKA 2002, KOZERA et al. 2006, SAWICKA , KUŚ, 2002 WICHROWSKA et al. 2009).

There is not much information in the available literature on the influence of insecticides on macronutrients in potato tubers. Hence, the objective of this field study was to determine the effect of an application of insecticides to control the Colorado beetle on the phosphorus and potassium content in edible potato tubers.

MATERIAL AND METHODS

We examined tubers harvested in a field experiment conducted over the years 2004-2006 at Zawady Experimental Farm, owned by the former University of Podlasie (University of Natural Sciences and Humanities). The experimental design was a split-plot arrangement of treatments with three replicates.

Two factors were examined in the experiment:

factor I – three mid-early edible potato varieties: Wiking, Mors, Żagiel;

factor II – six methods of Colorado beetle control:

1) control – no application of chemicals,
2) Actara 25 WG at the rate of 0.08 kg ha^{-1},
3) Regent 200 SC at the rate of 0.1 dm^3 ha^{-1},
4) Calypso 480 SC at the rate of 0.05 dm^3 ha^{-1},
5) Calypso 480 SC at the rate of 0.075 dm^3 ha^{-1},
6) Calypso 480 SC at the rate of 0.1 dm^3 ha^{-1}.

Potassium content was determined in the dry matter of potato tubers following wet mineralization and using atomic absorption spectrophotometry (AAS). Phosphorus was determined by means of the photometric method.

The results were statistically analysed by means of variance analysis. The F Fisher-Snedecor test was used to detect the significance of each source of variation and mean separation between variables was obtained by Tukey's Least Significant Difference test at the significance level of p=0.05.

Air temperatures and precipitation during the potato growing seasons varied in individual years (Table 1). In 2004, the total rainfall was 320.9 mm with the highest precipitation occurring in May – 97.0 mm. September was the driest month as it received only 19.5 mm rain. The average monthly air temperatures in 2004 varied and ranged from 8.0 to 18.9°C.

In the growing season of 2005, alternating months of extremely dry and very wet weather appeared. Average air temperatures in all the months of the potato growing season varied relative to the long-term means.

The highest rainfall, 358.6 mm, was recorded in 2006. Substantial fluctuations of precipitation were observed during the summer months, which are critical to potato growth and yielding.

Table 1

Characteristics of weather conditions during potato vegetation seasons (RSD Zawady)

Years	Months						Apr-Sept
	Apr	May	June	July	Aug	Sept	
Rainfalls (mm)							
2004	35.9	97.0	52.8	49.0	66.7	19.5	320.9
2005	12.3	64.7	44.1	86.5	45.4	15.8	268.8
2006	29.8	39.6	24.0	16.2	228.1	20.9	358.6
Multiyear average	52.3	50.0	68.2	45.7	66.8	60.7	343.7
Air temperature (^oC)							
2004	8.0	11.7	15.5	17.5	18.9	13.0	14.1
2005	8.7	13.0	15.9	20.2	17.5	15.0	15.0
2006	8.4	13.6	17.2	22.3	18.0	15.4	15.8
Multiyear average	7.7	10.0	16.1	19.3	18.0	13.0	14.0

RESULTS AND DISCUSSION

The results of our study demonstrated that potassium and phosphorus accumulation in potato tubers significantly depended on the cultivar, Colorado beetle control method and years (Tables 2, 3).

Of the examined cultivars, the highest potassium content was determined in the tubers of Mors, on average 27.19 g kg^{-1}. Significantly less potassium was found in Wiking (25.14 g kg^{-1} on average) and the least in cv. Żagiel tubers (23.67 g kg^{-1} on average). Most phosphorus was accumulated in the tubers of cv. Mars (3.490 g kg^{-1}, on average) and the least in cv. Wiking (2.910 g kg^{-1} on average). It agrees with the results reported by Kołodziejczyk and Szmigiel (2005), Mazurczyk (1994), Wichrowska et al. (2009) as well as Zarzecka and Mystkowska (2004), who demonstrated significant influence of cultivars on potassium and phosphorus content in potato tubers.

Application of insecticides was followed by an average increase of 0.15 to 0.61 g kg^{-1} in tuber potassium content compared with the content in the tubers of non-controlled potatoes (Table 2). A significant increase in potassium content was found in tubers harvested from all the "insecticidal" treatments, apart from the Actara 25 WG-sprayed plots.

Compared with the control content, the plant protection agents applied to control Colorado beetle significantly increased the phosphorus content of potato tubers by an average of 0.059 to 0.118 g kg^{-1} (Table 3). The lowest increase in phosphorus content, by 0.059 g kg^{-1}, was recorded in the treatment where Calypso 480 SC had been applied at the rate of 0.05 dm^3 ha^{-1}

Table 2

Content of potassium in the dry matter in potato tubers (g kg^{-1})

Potato beetle control methods	Years			Cultivars			Mean
	2004	2005	2006	Wiking	Mors	Żagiel	
1. Control treatment	26.05	24.46	24.54	24.76	27.03	23.24	25.01
2. Actara 25 WG 0.08 kg ha^{-1}	26.27	24.53	24.69	24.80	27.14	23.54	25.16
3. Regent 200 SC 0.1 dm^3 ha^{-1}	26.26	24.64	25.29	25.08	27.38	23.73	25.39
4. Calypso 480 SC 0.05 dm^3 ha^{-1}	26.50	24.48	25.12	25.13	27.10	23.86	25.37
5. Calypso 480 SC 0.075 dm^3 ha^{-1}	26.50	24.63	25.28	25.47	27.22	23.71	25.46
6. Calypso 480 SC 0.1 dm^3 ha^{-1}	26.81	24.65	25.41	25.61	27.29	23.96	25.62
Mean	26.39	24.56	25.05	25.14	27.19	23.67	-
$LSD_{0.05}$ for: years cultivars methods of controlling the potato beetle							0.20 0.20 0.19

Table 3

Content of phosphorus in the dry matter in potato tubers (g kg^{-1})

Potato beetle control methods	Years			Cultivars			Mean
	2004	2005	2006	Wiking	Mors	Żagiel	
1. Control treatment	2.803	2.992	3.552	2.847	3.408	3.093	3.116
2. Actara 25 WG 0.08 kg ha^{-1}	2.888	3.133	3.565	2.914	3.488	3.184	3.195
3. Regent 200 SC 0.1 dm^3 ha^{-1}	2.934	3.125	3.574	2.902	3.533	3.193	3.211
4. Calypso 480 SC 0.05 dm^3 ha^{-1}	2.878	3.089	3.559	2.896	3.495	3.154	3.175
5. Calypso 480 SC 0.075 dm^3 ha^{-1}	2.908	3.122	3.574	2.905	3.505	3.194	3.201
6. Calypso 480 SC 0.1 dm^3 ha^{-1}	2.971	3.150	3.582	2.995	3.511	3.198	3.234
Mean	2.897	3.102	3.563	2.910	3.490	3.169	-
$LSD_{0.05}$ for: years cultivars methods of controlling the potato beetle							0.018 0.018 0.027

whereas the highest increase (an average of 0.118 g kg^{-1}) was found following an application of the same insecticide but at the rate of 0.1 dm^3 ha^{-1}. Similar results have been reported by KRASKA and PAŁYS (2005). They applied insecticides with the following active ingredients: deltamethrin, bensultap and acetamiprid, and found an increase in potassium and phosphorus content of, respectively 2.4 and 0.3 g kg^{-1} in the dry matter of potato roots, compared with the control. By contrast, PROŚBA-BIAŁCZYK et al. (2002) ZCHUKOVA et al. (1992) found no changes in potassium and phosphorus concentrations due to application of plant protection agents. According to LESZCZYŃSKI (2002), application of insecticides and fungicides in most cases does not result in significant changes in chemical composition of potato tubers.

Studies by KOŁODZIEJCZYK and SZMIGIEL (2005) revealed that potassium content in potato tubers was significantly influenced by weather conditions. The highest potassium concentration was determined in the tubers of potato whose growing season was characterized by lower temperatures and higher rainfall, which was confirmed in the present study, as the highest potassium content (26.39 g kg^{-1}, on average) was found in the tubers of potatoes cultivated in 2004 and the lowest – in the dry 2005 (Table 2). On the other hand, studies by WADAS et al. (2007) demonstrated that more potassium was accumulated in tubers in the years characterized by lower total precipitation during the stage of tuber initiation.

Our analysis of the impact of atmospheric conditions on phosphorus content in potato tubers indicated that most phosphorus, 3.563 g kg^{-1} on average, was accumulated in the tubers of potato grown in 2006, when the highest precipitation was accompanied by the highest temperatures (Table 3). Least phosphorus, 2.897 g kg^{-1} on average, was accumulated in the tubers in 2004, which coincides with the findings by ZARZECKA and MYSTKOWSKA (2004). KLIKOCKA (2001) and MAZURCZYK and LIS (2001) found that weather conditions during the growing season had no significant influence on phosphorus content in potato tubers.

CONCLUSIONS

1. The insecticides applied to control the Colorado beetle increased potassium content in potato tubers compared with the control.

2. The highest phosphorus content was determined in the tubers of potato harvested from the plots sprayed with the following insecticides: Regent 200 SC and Calypso 480 SC, at the respective rates of 0.1 and 0.1 dm^3 ha^{-1}.

3. In the experiment discussed, phosphorus and potassium content in potato tubers was largely determined by cultivars and weather conditions in the individual years.

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