

CONTENT AND UPTAKE OF PHOSPHORUS AND CALCIUM WITH THE YIELD OF POTATO TUBERS DEPENDING ON CULTIVATION OPERATIONS

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Abstract

In 2002-2004, a study was carried out, based on a field experiment set up on soil of very good rye complex. The experiment was designed as randomized sub-blocks with three replications. Two methods of soil tillage, conventional and simplified tillage, and seven weeding methods such as application of the following herbicides 1) control object – without herbicides, 2) Plateen 41,5 WG , 3) Plateen 41,5 WG + Fusilade Forte 150 EC, 4) Plateen 41,5 WG + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC, 5) Barox 460 SL, 6) Barox 460 SL + Fusilade Forte 150 EC, 7) Barox 460 SL + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC), constituted experimental factors. Phosphorus content in the tubers of cultivar Wiking potato was determined by colorimetry and calcium was tested by the atomic absorption spectrophotometry method (AAS). Phosphorus and calcium content and their uptake with tubers yield significantly depended on the tillage methods and weed control methods as well as weather conditions in the study years. Potato tubers from the simplified tillage cultivation had more phosphorus than tubers whose cultivation was based on the conventional tillage, in contrast to calcium, which was more abundant in tubers from the conventional method. The herbicides significantly reduced the phosphorus content and increased the calcium content compared with the control object. Phosphorus and calcium uptake by potato was significantly higher in the conventionally tilled treatments compared with the simplified method, and in the herbicide-treated plots compared with the mechanically cultivated control treatment.

Key words: potato, phosphorus, calcium, content, uptake.

ZAWARTOŚĆ ORAZ POBRANIE FOSFORU I WAPNIA Z PLONEM BULW ZIEMNIAKA W ZALEŻNOŚCI OD ZABIEGÓW AGROTECHNICZNYCH

Abstrakt

W latach 2002-2004 przeprowadzono badania oparte na doświadczeniu polowym założonym na glebie kompleksu żytniego bardzo dobrego. Doświadczenie założono metodą losowanych podbloków w trzech powtórzeniach. Badanymi czynnikami były 2 sposoby uprawy roli – tradycyjna i uproszczona oraz 7 sposobów pielęgnacji z zastosowaniem herbicydów 1) obiekt kontrolny – bez herbicydów, 2) Plateen 41,5 WG , 3) Plateen 41,5 WG + Fusilade Forte 150 EC, 4) Plateen 41,5 WG + Fusilade Forte 150 EC + adiuwant Atpolan 80 EC, 5) Barox 460 SL, 6) Barox 460 SL + Fusilade Forte 150 EC, 7) Barox 460 SL + Fusilade Forte 150 EC + adiuwant Atpolan 80 EC). Zawartość fosforu w suchej masie bulw ziemniaka oznaczono kolorymetrycznie, a wapnia – metodą absorpcyjnej spektrofotometrii atomowej (ASA). Zawartość fosforu i wapnia i ich pobranie z plonem bulw zależały istotnie od sposobów pielęgnacji i warunków pogodowych w latach badań. Więcej fosforu zawierały bulwy ziemniaka z uprawy uproszczonej w porównaniu z tradycyjną, a więcej wapnia z uprawy tradycyjnej. Herbicydy zastosowane w pielęgnacji wpłynęły na obniżenie zawartości fosforu i podwyższenie zawartości wapnia w porównaniu z bulwami z obiektu kontrolnego. Pobranie fosforu i wapnia z plonem bulw ziemniaka było istotnie większe na obiektach z uprawą tradycyjną niż uproszczoną oraz na obiektach odchwaszczanych chemicznie w stosunku do obiektu kontrolnego pielęgnowanego wyłącznie mechanicznie.

Słowa kluczowe: ziemniak, fosfor, wapń, zawartość, pobranie.

INTRODUCTION

Application of herbicide to potato fields limits harmful effect of weeds. However, herbicides can cause changes in the chemical composition of potato tubers (LESZCZYŃSKI 2002, RICHARDSON et al. 2004, ZARZECKA, MYSTKOWSKA 2004). Quality of potato tubers depends mainly on a potato genotype (MAZURCZYK 1994, TEKALIGN, HAMMES 2005), soil (CZEKAŁA, GŁADYSIAK 1995, KOŁODZIEJCZYK, SZMIGIEL 2005) and weather conditions (NOWAK et al. 2004, WICHROWSKA 2008) as well as cultivation technology (KLIKOCKA 2001) and methods of weed control (CEGLAREK, KSIĘŻAK 1992, KLIKOCKA 2001, ZARZECKA et al. 2002). According to MAZURCZYK (1994), the content of macroelements in tubers is variable, closely connected with climatic conditions during the vegetation. With respect to the influence of plant protection products on the chemical composition of tubers, researchers seem to disagree (WICHROWSKA 2008, WYSZKOWSKI, CIEĆKO 2001, ZARZECKA et al. 2002). Therefore, the aim of this research was to determine the effect of herbicides and tillage systems on the content and uptake of phosphorus and calcium with the yield of potato tubers.

MATERIAL AND METHODS

The study was carried out on the basis of a field experiment set up on soil of very good rye complex. Selected soil chemical properties prior to the experiment are shown in Table 1. Two methods of soil tillage, the conventional and simplified tillage, and seven weeding methods such as application

Table 1

Chemical and physical properties of the soil

Specification	2002	2003	2004
Organic matter (g kg^{-1})	11.3	11.3	11.5
Soil pH (1 M KCl)	6.5	6.4	5.6
Content of available nutrients (mg kg^{-1}):			
– P	38.8	43.0	62.5
– K	150.3	102.2	103.9
– Mg	70.0	157.0	159.0

of the following herbicides (1) control object – without herbicides, 2) Plateen 41,5 WG, 3) Plateen 41,5 WG + Fusilade Forte 150 EC, 4) Plateen 41,5 WG + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC, 5) Barox 460 SL, 6) arox 460 SL + Fusilade Forte 150 EC, 7) Barox 460 SL + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC), constituted experimental factors. Organic fertilization was applied in the form of manure at $25 \text{ t} \cdot \text{ha}^{-1}$. Mineral fertilizers were applied at the following concentrations: 90 kg N , 32.9 kg P and $112.1 \text{ kg K} \cdot \text{ha}^{-1}$. Each plot was 25 m^2 in surface area. Phosphorus content in tubers of cv. Wiking potato was determined by colorimetry and calcium - by atomic absorption spectrophotometry (AAS). The results were statistically processed with the analysis of variance and the significance of differences was determined using Tukey's test. Meteorological conditions over the period of the study varied and are presented in Table 2.

Table 2

The mean temperature and rainfall from April-September in Zawady in 2002-2004

Year	Meteorological conditions from April to September			
	rainfalls sum (mm)	in comparison to long term (%)	mean temperature ($^{\circ}\text{C}$)	in comparison to long term (%)
2002	310.1	-9.8	16.2	15.7
2003	132.5	-61.4	15.5	10.7
2004	320.9	-6.6	14.1	0.7
1981-1995	343.7	-	14.0	-

RESULTS AND DISCUSSION

Content and uptake phosphorus with yield of tubers. Phosphorus content in the tubers of cv. Wiking edible potato ranged from 2.310-2.920 g kg⁻¹ d. m., and significantly depended on soil tillage systems and weed control methods as well as precipitation and temperature in the study years (Tables 3, 5). Phosphorus concentration in tubers was similar to the values reported by other authors (KARIM et al. 1997, KOŁODZIEJCZYK, SZMIGIEL 2005, TEKALIGN, HAMMES 2005, WYSZKOWSKI, CIEĆKO 2001). Higher phosphorus content was found in tubers of potato under the simplified tillage compared with the conventional tillage. Similar changes were observed by other authors who tested simplified tillage in potato cultivation (EKEBERG, RILEY 1996, KLIKOCA 2001). The herbicides reduced the phosphorus content from 0.176 to 0.235 g kg⁻¹ d.m., which was less than the phosphorus level in tubers from the mechanically controlled treatment, KLIKOCA (2001), ZARZECKA, MYSTKOWSKA (2004) observed less phosphorus in tubers following application of Sencor 70 WG and Basagran 600 SL.

In our tests, was found that phosphorus uptake by potato tubers was significantly higher in the conventionally tilled treatments (on average 21.18 kg ha⁻¹) than in the treatments where some cultivation operations had been abandoned (on average 20.08 kg ha⁻¹) – Table 3. Increased phosphorus uptake was also recorded after the application of herbicides, where it was on average higher by 0.42 kg ha⁻¹ than in the mechanically weeded object. Phosphorus uptake with the yield of tubers was higher about 5 kg ha⁻¹ than the amount cited by NOWAK et al. (2004).

Content and uptake of calcium with yield of tubers. Calcium content in tubers ranged from 0.710 to 0.850 g kg⁻¹ d. m. (Tables 4, 5) and was comparable to the content reported by other authors (PROŚBA-BIAŁCZYK et al. 2002, TEKALIGN, HAMMES 2005, WYSZKOWSKI, CIEĆKO 2001). Calcium concentration in the examined potatoes depended on tillage and weed control methods, as well as weather conditions during the years of the study. Owing to more tillage operations in the conventional tillage, the calcium content in tubers was superior to that from the simplified cultivation, an observation which has been reported in other studies (KLIKOCA 2001). The herbicides applied in potato cultivation increased calcium concentration (from 0.038 to 0.110 g kg⁻¹) compared with the tubers of mechanically cultivated potatoes. ALSO, ZARZECKA et al. (2002) demonstrated that herbicides slightly increased the calcium content in tubers, but the difference was not statistically significant. In contrast, PROŚBA-BIAŁCZYK et al. (2002), WYSZKOWSKI, CIEĆKO (2001) found that levels of phosphorus, magnesium and calcium remained relatively stable and were not affected by plant protection chemicals.

Calcium uptake, coupled with yield formation, was significantly affected by the experimental factors and thermal and precipitation conditions over the studied years (Tables 4, 5). Higher calcium uptake from per 1 ha and

Table 3

Content and uptake of phosphorus with the yield of potato tubers

Weed control methods	Content of P ($g\ kg^{-1}$ d.m.)				Uptake of P ($kg\ ha^{-1}$)				Uptake of P ($kg\ t^{-1}$ of yield d.m.)			
	tillage systems		mean	tillage systems		mean	tillage systems		mean	tillage systems		mean
	conventional	simplified		conventional	simplified		conventional	simplified				
1.	2.727	2.773	2.750	20.84	19.78	20.31	2.679	2.717	2.698			
2.	2.510	2.637	2.574	20.22	20.25	20.24	2.493	2.593	2.543			
3.	2.467	2.570	2.519	20.69	20.68	20.69	2.454	2.528	2.491			
4.	2.497	2.540	2.519	23.15	20.55	22.18	2.492	2.429	2.461			
5.	2.520	2.537	2.529	20.62	19.17	19.86	2.509	2.503	2.506			
6.	2.493	2.537	2.515	20.83	19.36	20.10	2.486	2.511	2.499			
7.	2.507	2.577	2.542	21.89	20.83	21.20	2.490	2.594	2.542			
Mean	2.532	2.596	2.564	21.18	20.08	20.63	2.515	2.554	2.534			
Mean for 2-7 object	2.499	2.566	2.533	21.23	20.14	20.70	2.487	2.526	2.507			
LSD _{0.05} between: tillage systems (I) weed control methods (II) interaction I x II			0.020 0.040 0.044			0.34 1.13 n.s.			0.032 0.100 n.s.			

n.s. – non-significant differences

Table 4

Content and uptake of calcium with the yield potato tubers

Weed control methods	Content of Ca (g kg ⁻¹ d.m.)			Uptake of Ca (kg ha ⁻¹)			Uptake of C (kg t ⁻¹ of yield d.m.)		
	tillage systems		mean	tillage systems		mean	tillage systems		mean
	conventional	simplified		conventional	simplified		conventional	simplified	
1.	0.737	0.710	0.724	5.685	5.113	5.399	0.731	0.702	0.714
2.	0.767	0.757	0.762	6.007	5.934	5.971	0.741	0.760	0.751
3	0.810	0.777	0.794	6.831	6.339	6.585	0.810	0.775	0.793
4.	0.787	0.753	0.770	7.232	6.293	6.762	0.778	0.744	0.761
5.	0.800	0.773	0.787	6.526	5.877	6.202	0.794	0.767	0.781
6.	0.850	0.817	0.834	7.146	6.347	6.747	0.853	0.823	0.838
7.	0.787	0.753	0.770	6.892	6.030	6.461	0.784	0.751	0.768
Mean	0.791	0.763	0.777	6.614	5.990	6.302	0.784	0.760	0.772
Mean for 2-7 object	0.800	0.772	0.786	6.772	6.137	6.455	0.793	0.770	0.782
LSD _{0.05} between: tillage systems (I) weed control methods (II) interaction I x II			0.006 0.028 n.s.			0.070 0.380 n.s.			0.011 0.040 n.s.

n.s. – non-significant differences

converted into 1 tone of tuber yield was determined for the conventional tillage compared with the simplified method, and for the herbicide-treated plots compared with the control (mechanical weeding). Accumulation of elements in plant material is a function of yield and the content of the element determined. ALSO, NOWAK et al. (2004) found that uptake of nutrients depended on the yield and analyzed component.

Table 5

Effect of weather conditions during the growing period on the content and uptake of phosphorus and calcium with the yield of potato tubers

Year	Content (g kg ⁻¹ d.m.)		Uptake (kg ha ⁻¹)		Uptake (kg t ⁻¹ of yield d.m.)	
	P	Ca	P	Ca	P	Ca
2002	2.310	0.760	23.35	7.666	2.305	0.757
2003	2.470	0.845	16.93	5.796	2.464	0.844
2004	2.920	0.725	21.62	5.444	2.864	0.721
LSD _{0.05}	0.030	0.009	0.52	0.107	0.051	0.010

Phosphorus and calcium content and their uptake coupled with yield formation varied during the research (Table 5). In the 2004 season, the content of phosphorus was the highest as the precipitation and the temperature were favourable for potato growth. In contrast, tubers harvested in the warm and dry 2003 season were the richest in calcium. Phosphorus and calcium uptake was stimulated by the weather conditions during the hottest year 2002. These findings are supported by studies of other authors (CZEKAŁA, GŁADYSIAK 1995, KOŁODZIEJCZYK, SZMIGIEL 2005).

CONCLUSIONS

1. Introduction of simplifications to soil tillage result in increased phosphorus and decreased calcium content in tubers, and in a reduced uptake of these elements by potato yield, compared with the conventional tillage.

2. When potatoes were cultivated using herbicide-based weed control, the phosphorus content in tubers was smaller and calcium content higher than in the tubers weeded mechanically.

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