J. Elementol. 2009, 14(2): 249–256

EFFECT OF CULTIVATION FACTORS ON MAGNESSIUM CONTENT IN AND REMOVAL BY THE POTATO TUBER CROP

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Abstract

Studies were carried out on samples obtained from a field experiment conducted on light loamy soil in 2002-2004. The experiment was set up as randomized sub-blocks with three replications. Two methods of soil tillage, conventional and simplified, were compared as well as seven weed control methods including application of herbicides or their mixtures: 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). Magnesium content and its removal by potato tuber crop significantly depended on soil tillage methods, weed control methods and weather conditions over the growing season. More magnesium was contained in tubers harvested from the plots where reduced tillage had been applied (1.771 g kg^{-1} on average), compared with 1.762 g kg^{-1} under the conventional method. Herbicides and their mixtures applied to control weeds in the potato field significantly increased magnesium content in tubers and its removal by tuber yield by an average 2.7% and 11.0%, respectively, compared with the control where weeds were controlled by means of mechanical cultivation.

Key words: potato tubers, magnesium, content, uptake.

WPŁYW ZABIEGÓW AGROTECHNICZNYCH NA ZAWARTOŚĆ I POBRANIE MAGNEZU Z PLONEM BULW ZIEMNIAKA

Abstrakt

Badania wykonano na próbach pochodzących z doświadczenia polowego przeprowadzonego w latach 2002-2004 na glebie o składzie piasku gliniastego lekkiego. Eksperyment

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założono metodą losowanych podbloków w trzech powtórzeniach. Porównywano dwa sposoby uprawy roli – tradycyjną i uproszczoną oraz siedem sposobów odchwaszczania z udziałem herbicydów i ich mieszanin: Plateen 41,5 WG, Plateen 41,5 WG + Fusilade Forte 150 EC, Plateen 41,5 WG + Fusilade Forte 150 EC + adiuwant Atpolan 80 EC, Barox 460 SL, Barox 460 SL + Fusilade Forte 150 EC, Barox 460 SL + Fusilade Forte 150 EC + adiuwant Atpolan 80 EC, obiekt kontrolny pielęgnowany mechanicznie. Zawartość magnezu i jego pobranie z plonem bulw ziemniaka zależały istotnie od sposobów uprawy roli, sposobów odchwaszczania i warunków atmosferycznych w okresie wegetacji. Więcej magnezu zawierały bulwy ziemniaka zebrane z obiektów uprawy uproszczonej – średnio 1,771 g kg^{-1} w porównaniu z tradycyjną – średnio 1,762 g kg^{-1}. Herbicydy i ich mieszaniny zastosowane do odchwaszczania plantacji ziemniaka podwyższały istotnie zawartość magnezu w bulwach – średnio o 2,7% i jego pobranie z plonem bulw – średnio o 11,0% w porównaniu z obiektem kontrolnym pielęgnowanym mechanicznie.

Słowa kluczowe: bulwy ziemniaka, magnez, zawartość, pobranie.

INTRODUCTION

Potato tubers contain 1-1.2% mineral compounds, mainly potassium, phosphorus, magnesium and calcium. Consumption of 200g of potatoes satisfies 12-30% of human needs with respect to these elements (Leszczyński 2000). Mineral element content in potato tubers is affected by cultivar properties (Karim et al. 1997, Prośba-białczyk et al. 2002, Zarzecka et al. 2002), agronomic factors (Rogozińska et al. 1995, Wyszkowski 1996, Klikocka 2001, Nowak et al. 2004) and weather conditions over the growing period (Czekała, Gładysiak 1995, Zarzecka, Gąsiorowska 2002). The results of studies concerning impact of herbicides and soil cultivation methods on macroelement content in tubers vary as much as the researchers' opinions (Ceglarek, Księżak 1992, Klikocka 2001). Thus, the objective of the present work has been to determine the effect of soil tillage methods and weed control methods in potato cultivation on magnesium content and its removal by potato tuber crop.

MATERIAL AND METHODS

The experimental material consisted of cultivar Wiking edible potato tubers obtained from a field experiment conducted in 2002-2004. The experiment was established on light loamy soil and belonged to the very good rye complex. Selected chemical properties (organic matter, pH, available forms of phosphorus, potassium and magnesium) of the experimental field soil are presented in Table 1. The experiment was designed as randomised sub-blocks with three replications. The following factors were examined: I – two methods of soil tillage: conventional and simplified, II – seven methods of weed control including herbicide application (Table 2). Uniform mineral and or-

Table 1

Chemical and physical characteristics of the soil

Specification	2002	2003	2004
Organic matter (g kg^{-1})	11.3	11.3	11.5
pH 1 mol KCl dm^3	6.5	6.4	5.6
Content P (mg kg^{-1})	38.8	43.0	62.5
Content K (mg kg^{-1})	150.3	102.2	103.9
Content Mg (mg kg^{-1})	70.0	157.0	159.0

Table 2

Experimental factors

I. Tillage systems	1. Traditional (skimming + fall ploughing + harrowing + + cultivating + harrowing) 2. Simplified (skimming + cultivating)
II. Weed control methods	1. Control object - mechanical weeding until and after potato rising 2. Plateen 41.5 WG (metribuzin + flufenacet) 2.0 kg ha^{-1} 3. 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) 4. 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) 5. Barox 460 SL (bentazone + MCPA) 3.0 dm^3 ha^{-1} 6. 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) 7. Barox 460 SL (bentazone + MCPA) 2.4 dm^3 ha^{-1} + Fusilade Forte 150 EC (fluazyfop-P-butyl) 2.0 dm^3 ha^{-1} + adjuvant Atpolan 80 EC 1.5 dm3 ha-1 (mixture)

ganic fertilization comprising 90 kg N, 32.9 kg P and 112.1 kg K ha^{-1}, and 25.0 t ha^{-1} (farmyard manure) was applied.

Magnesium content was determined in tuber dry matter following wet mineralization by the method of atomic absorption spectrophotometry (AAS). Magnesium removal by tuber yield was calculated from the product of tuber dry matter yield and Mg concentration. The results were statistically analysed with the analysis of variance and the significance of differences was determined using Tukey's test.

Weather conditions over the period of studies varied. The year 2002 was warm and wet with high temperatures during the months of tuber formation (July and August). The next year was also warm but the precipitation was insufficient as it reached barely 48.3% of long-term average sum. The year 2004 was wet and cold. Air temperatures and precipitation constituted 116.6 and 95.0%, respectively, of the long-term averages (Table 3).

Table 3

Weather conditions in 2002-2004

Years	Months						Mean value
	Apr	May	June	July	Aug	Oct	
Temperature (°C)							
2002	9.0	17.0	17.2	21.0	20.2	12.9	16.2
2003	7.1	15.6	18.4	20.0	18.5	13.5	15.5
2004	8.0	11.6	15.4	17.5	18.9	13.0	14.1
Multiyear mean 1981-1995	7.7	10.0	16.1	19.3	18.0	13.0	14.0
Rainfall (mm)							Sum
2002	12.9	51.3	61.1	99.6	66.5	18.7	310.1
2003	13.6	37.2	26.6	26.1	4.7	24.3	132.5
2004	35.9	97.0	52.8	49.0	66.7	19.5	320.9
Multiyear mean 1981-1995	52.3	50.0	68.2	45.7	66.8	60.7	343.7

RESULTS AND DISCUSSION

Under conditions of the experiment the average magnesium content in potato tubers ranged from 1.645 to 1.940 g kg^{-1} (Table 4). Significant effect of the soil tillage methods, weed control methods and moisture and thermal conditions on the magnesium concentration occurred. Magnesium content in tubers was similar to the levels reported by other authors (Prośba-Białczyk et al. 2002, Kołodziejczyk, Szmigiel 2005, Tekaligh, Hammes 2005, Kozera et al. 2006). In the present study the reduced soil tillage increased the accumulation of magnesium compared with the conventional tillage. In contrast, Klikocka (2002) recorded an increased magnesium content in tubers harvested from plots which had been conventionally cultivated in comparison with the simplified cultivation. In their studies Klikocka and Komisarczuk (2000) observed that the use of no-plough tillage increased magnesium content in spring triticale grain compared with the plough-based cultivation.

The herbicides applied to control weeds in potato fields increased magnesium concentration in tubers by an average of 2.7% compared with mechanical weed control. The highest content of the macroelement appeared in tubers of potato plants sprayed with mixtures of Plateen 41.5 WG + Fusilade Forte 150 EC (on average 1.798 g kg^{-1}), and Barox 460 SL + Fusilade Forte 150 EC (on average 1.788 g kg^{-1}). Similar changes were observed by Zarzecka, Gąsiorowska (2002), who used herbicide mixtures and two applications of weed control chemicals. In contrast, Klikocka (2002) found no influ-

Table 4

Content of magnesium in potato tubers (g kg^{-1} d.m.)

Weed control methods	Tillage systems		Years			Mean
	traditional	simplified	2002	2003	2004	
1. Control object	1.719	1.734	1.645	1.865	1.670	1.727
2. Plateen 41,5 WG	1.763	1.777	1.694	1.918	1.699	1.770
3. Plateen 41,5 WG + Fusilade Forte 150 EC	1.794	1.807	1.780	1.930	1.692	1.798
4. Plateen 41,5 WG + Fusilade Forte 150 EC + Atpolan 80 EC	1.738	1.743	1.677	1.890	1.657	1.741
5. Barox 460 SL	1.765	1.787	1.710	1.916	1.702	1.776
6. Barox 460 SL + Fusilade Forte 150 EC	1.792	1.785	1.720	1.940	1.705	1.788
7. Barox 460 SL + Fusilade Forte 150 EC + Atpolan 80 EC	1.769	1.769	1.694	1.895	1.714	1.769
Mean	1.762	1.771	1.703	1.909	1.691	1.767
Mean for 2-7 object	1.769	1.778	1.713	1.915	1.695	1.774
$LSD_{0.05}$ – between:						
tillage systems (I)						0.004
weed control methods (II)						0.021
years (III)						0.007
interaction (I xII)						0.008
(II x III)						0.038
(I x II x III)						0.035

ence of chemical or mechanical and chemical weed control on the level of magnesium in potato tubers. According to Rola, Kieloch (2001), pesticides sprayed in a field to protect crop plants do not usually differentiate significantly the content of macroelements in plants. However, when crops compete with weeds, they can more easily take up individual elements.

Our analysis of the effect of the weather conditions during the experiment revealed that the highest amount of magnesium was in the tubers harvested in the warm and dry 2003. Differentiation of the magnesium content in tubers depending on weather conditions has also been reported in the papers by Klikocka (2001), Zarzecka et al. (2002) and Kołodziejczyk, Szmigiel (2005).

Magnesium removal by potato tuber crop was influenced by the experimental factors and weather conditions over the study years (Table 5). More magnesium was removed from conventionally tilled plots (on average 14.78 kg ha^{-1}) compared with the plots where some cultivation operations were abandoned (on average 13.92 kg ha^{-1}). It resulted from the fact that higher potato tuber yield was harvested from conventionally-tilled plots. Increased removal of magnesium, compared with the mechanically-tilled control, also

Table 5

Uptake of magnesium with the yield of potato tubers (kg ha^{-1})

Weed control methods	Tillage systems		Years			Mean
	traditional	simplified	2002	2003	2004	
1. Control object	13.49	12.75	16.12	11.61	11.64	13.12
2. Plateen 41,5 WG	14.19	13.72	17.13	12.53	12.21	13.96
3. Plateen 41,5 WG + Fusilade Forte 150 EC	15.05	14.74	18.87	13.03	12.80	14.90
4. Plateen 41,5 WG + Fusilade Forte 150 EC + Atpolan 80 EC	15.95	14.66	18.76	12.98	14.17	15.30
5. Barox 460 SL	14.11	13.60	16.43	13.45	12.19	14.02
6. Barox 460 SL + Fusilade Forte 150 EC	14.94	13.74	16.40	13.78	12.85	14.34
7. Barox 460 SL + Fusilade Forte 150 EC + Atpolan 80 EC	15.43	14.20	16.97	14.36	13.12	14.82
Mean	14.78	13.92	17.24	13.11	12.71	14.35
Mean for 2-7 object	14.95	14.11	17.43	13.36	12.89	14.56
$LSD_{0.05}$ – between:						
tillage systems (I)						0.16
weed control methods (II)						0.74
years (III)						0.25
interaction (I xII)						0.29
(II x III)						1.29
(I x II x III)						n.s.

n.s. – not significant

occurred after herbicide application. The increase ranged from 0.84 kg ha^{-1}, following spraying with Plateen 41.5 WG (treatment 2) to 2.18 kg ha^{-1} following an application of a mixture of Plateen 41.5 WG + Fusilade Forte 150 EC + adjuvant Atpolan 80 EC, compared with the mechanical control. Higher magnesium uptake was mainly associated with higher potato yields in the plots where weeds were chemically controlled. Magnesium removal associated with tuber yield was similar to the values cited by GRZEŚKIEWICZ and MAZURCZYK (2001), ranging from 13.1 to 20.1 kg ha^{-1}.

CONCLUSIONS

1. Reductions in soil tillage increased magnesium content in potato tubers compared with the conventional tillage. However, the removal of the element by potato tuber crop was higher in conventionally tilled plots.

2. Herbicides applied in potato cultivation increased magnesium content in tubers compared with the control.

3. Magnesium concentration and its removal by potato crop increased as a result of intensification of weed control in potato field.

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