EFFECT OF IRRIGATION ON THE MINERAL NUTRIAL CONTENT OF DIFFERENT POTATO VARIETIES

Ábrahám Éva Babett*, Sárvári Mihály*

*University of Debrecen Faculty of the Agricultural, and Food Sciences and Environmental Management, Institute of Crop Sciences, Department of Crop Production and Applied Ecology, Debrecen, Hungary, e-mail: abraham.eva@agr.unideb.hu; sarvari@agr.unideb.hu

Abstract

Effect of irrigation and year effect was investigated on the mineral content of different potato varieties under irrigated and non-irrigated circumstances. We tested 9 medium early varieties in 2004, 2005 and 2006. We were searching for the effect of irrigation on the mineral content of different potato varieties and the correlation between the content of the minerals.

Key words: potato, varieties, irrigation, element content

INTRODUCTION

In order to guarantee healthy foods researches are needed on the concentration of certain nutrients such as macro- and micro-essential metals in tubers (Tamasi et al., 2015).

Toxic metals accumulate in the soils and are subsequently taken up by the crops and can pose serious problems to humans and animals, and they pollute the environment (Taylor and Percival, 2001; Thorburn et al., 2003).

The highest quality of potato tubers mainly depends on the variety (Polgár, 2002) but ecological conditions (amount and distribution of precipitation, temperature, and soil type), applied agro-technics and postharvest technologies have effect on its realization (Győri et al. 2004; Kruppa et al., 2003a).

The ash content and the proportion of mineral nutrition appertain to the quality. The ash content of potato tubers is 1.0-1.2% (Gasztonyi, 1992; Lásztity et al., 1983; Pais, 1992; Pais, 1993).

Among the minerals potato tubes contains the highest amount from potassium, and then follow the phosphorous, sulphur and magnesium content of tubers (Győri et al., 2004).

According to the results of Béres (1977) the yield is in closed positive correlation with the accumulation of N and Zn content, and in week positive correlation with the accumulation of Cu and Mo content.

MATERIAL AND METHOD

In our experiment we examined the yield and some quality parameters of 9 medium-early varieties in large plots. Among the examined varieties, 3

were Dutch (Kuroda Desirée és Kondor), and 6 were Hungarian breeding (Rioja, Lorett, Góliát, Kánkán, Hópehely, White Lady).

The 9 varieties were examined in 4 replications in randomized blocks: two replications were irrigated and two were non-irrigated. Beside the yield of the varieties, we examined the effect of irrigation on the mineral content of the potato tubers.

2 way-anova and Pearson correlation coefficient were calculated using SPSS for Windows 13.0 statistical software package.

1.1. Weather conditions

In 2004, during the vegetation period of the potato, the amount of the precipitation was 342.6 mm, 2.6 mm lower than the 30 years' average (345.1 mm), but the distribution of precipitation was unfavourable.

May was extremely dry; the monthly amount of precipitation was only 17 mm. In July the quantity of rainfall was twice higher than the average (142 mm), which was unfavourable in terms of pathological parameters. The average monthly temperature was 19.3°C in June and 21.1°C in July, which is higher than the requirement of the potato (17-18°C).

In 2005, the amount of precipitation was sufficient during the vegetation period of the potato, and also the distribution of precipitation was relatively even. The amount of precipitation only in June (54.3 mm) was lower than the average of the last 30 years (79.5 mm). The amount of precipitation was higher than the 30 years' average in April, May, July, August (with 75 mm) and in September. The average monthly temperature was about the 30 years' average; the monthly average temperature was 21°C in July.

In 2006, during the vegetation period of the potato the amount of rainfall was 326.2 mm, 18.9 mm lower than the 30 years' average (345.1 mm). The amount of precipitation in April was 92.3 mm, and the planting date was at the end of April. The amount of precipitation was about the 30 years' average in May, June and August, but the monthly amount of precipitation in July was almost the half of the average. In July, in the most critical period the average monthly temperature was 20.3°C.

1.2. Soil characteristics of the experimental site

The experiment was carried out at the experimental site of the Farm and Regional Research Institute, University of Debrecen, at Látókép.

The soil of the experiment field was calciferous chernozem developed on loess with deep mould. The experiment's soil is in good condition, according to the soil physics it is classified as a middle bound loam soil. The thickness of the mould layer is between 80 and 90 cm, and the evenly

mould layer's average mould content is 2.8%. $CaCO_3$ appears in the transitional layer of the soil profile, at the depth of 70–100 cm.

The cultivated layer's acidity (KCL pH) is between 6.3 and 6.5, the N content is 0.12-0.15%. The experimental site's soil has good potassium content (240 mg kg^{-1}), the phosphorous content is variable, the average phosphorous content is medium (133 mg kg^{-1}).

The minimum field water capacity (FCmin) ranges between 33.65 and 46%, the non-available water (NW) ranges between 8.5-15.7% in the 0-200 cm soil layer. Soil water table is in 8-10 m depth, the soil can store a substantial amount of water.

1.3. Agro-technology used in the experiment

The applied fertilizer dose was 165 kg ha^{-1} N, 210 kg ha^{-1} P_2O_5, and 220 kg ha^{-1} K_2O in all the 3 year. The experiment was set up on 50 m^2 parcels, after winter wheat (2004 and 2006) and two rowed barley (2005) as a forecrop. The plant density was 51.000 plants ha^{-1}.

Table 1

Main agro-technical parameters

Name	2004	2005	2006
Date of fertilizer	9 April: N: 160; P_2O_5: 120; K_2O: 220 kg ha^{-1}	18 April N: 160; P_2O_5: 120; K_2O: 220 kg ha^{-1}	24 April: N: 160; P_2O_5: 120; K_2O: 220 kg ha^{-1}
Planting date	21-22 April	2 May	24 April
Irrigation	22 May: 15 mm (all repetitions)	2 June: 30 mm	19 July: 30 mm
	5 June: 25 mm	28 July: 30 mm.	13 July: 30 mm
	11 June: 30 mm		
	8 July: 30 mm		
Harvesting	22 September	6-27 September	25 September

The replications were irrigated 4 times in 2004: on 22 May 2004 with 15 mm; on 05 June 2004 with 25 mm; on 11 June 2004 with 30 mm; on 08 July 2004 with 30 mm.

In May we had to irrigate all of the repetitions, because of the drought and the chapped soil.

In 2005 the dates of irrigation were 01 June and 28 July with 30 mm. In 2006 the repetitions were irrigated 2 times: 19 and 30 July with 30 mm. *Table 1* shows the main agro-technical parameters.

RESULTS AND DISCUSSION

The experiment was for the determination of the element content of the varieties and the revelation of correlation between the element content and other quality parameters. The element content is concerned mg 1000g

dry matter content^{-1}, but I used only the mg notation for the sake of simplicity. Table 2 shows the mineral contents in the average of the examined varieties in 2004, 2005 and 2006, under non irrigated and irrigated circiumstances.

Potassium content of the potato tubers depend on the year. The potassium content was lower in 2006 in the most rainy year than in 2004 and 2005. In 2004 and 2005 the average potassium content ranged between 18000-19000 mg, while in 2006 the average potassium content ranged between 13000-14000 mg.

There is positive correlation between the potassium content of potato tubers and the amount of precipitation in the breeding season (r=0.388**) and the amount of precipitation in July (0.561**) as well. In the average of 2004-2006 years, irrigation did not influence the potassium content ($LSD_{5\%}$=1066 mg) considerably.

There was not significant difference between the average potassium content of the varieties ($LSD_{5\%}$=6851 mg).

Table 2

Average mineral content of the examined potato varieties under non-irrigated and irrigated conditions

	Non-irrigated			Irrigated		
	2004	2005	2006	2004	2005	2006
K	18190.96	18013.63	14688.25	18086.16	19324.80	13572.28
Ca	534.18	424.84	656.91	513.30	424.64	500.20
Mg	764.41	900.72	930.10	764.17	926.98	864.70
Na	77.35	71.27	91.38	84.84	82.19	84.60
Fe	47.26	61.30	89.84	47.48	64.08	74.48
Mn	5.45	4.95	6.05	5.74	5.11	5.66
B	6.10	5.56	5.13	5.72	6.00	4.55
Cu	4.89	6.80	3.81	4.85	6.45	3.82
Zn	13.04	11.21	10.81	12.16	11.40	11.24

There was positive correlation between the potassium and the magnesium content (2004: 0.628**, 2005: 0.564**, 2006: 0.604**).

The average calcium content of potato tubers was over 500 mg in 2004 and 2006, while in 2005 it was just 425 mg both under non-irrigated and irrigated cultivation.

The calcium content decreased at the most of the varieties as a result of irrigation in every year during the experiment.

Irrigation decreased the calcium content in the average of the 3 years as well (non-irrigated: 538.64 mg, irrigated: 479.38 mg, $LSD_{5\%}$=48.48 mg). We did not find significant difference between the calcium content of the varieties ($LSD_{5\%}$=318.44 mg).

There was positive correlation between the calcium and the boron content (2004: 0.398*, 2005: 0.490*, 2006: 0.386*), and between the calcium and iron content in 2005 (0,400*) and 2006 (0.348*).

The magnesium content of potato tubers was the lowest in 2004; the average magnesium content was 764 mg in 2004, while in 2005 and 2006 the average magnesium content ranged between 865-930 mg.

The amount of precipitation and the year effect influences the magnesium content of tubers (r=0.301**).

The distribution of precipitation is important in the point of view of the magnesium content of tubers, there was negative correlation between the magnesium content and the amount of precipitation in June (r=-0.423**).

The magnesium content of Góliát and Lorett varieties (800-1030 mg) was high in every year during the experiment, while the magnesium content of the other varieties were variable. In the average of the 3 year of the experiment the irrigation did not influenced the magnesium content considerably.

There was positive correlation between the magnesium and the potassium and manganese content (2004: 0.384*, 2005: 0.546**, 2006: 0.631**).

The average sodium content of potato tubers ranged between 70-90 mg. The sodium content was variable; tendencies and differences among the varieties could not be figured out.

The sodium content in the average of the 3 years of the experiment was 80.00 mg under irrigated, and 83.87 mg under non-irrigated cultivation. Irrigation did not influence the sodium content according to the result of the 3 year ($LSD_{5\%}$=9.42 mg).

There was positive correlation between the sodium and the iron content (2004: 0.409*. 2005: 0.346*, 2006: 0.634**).

The iron content of potato tubers was the lowest in 2004 (47 mg) and was the highest in 2006 (75-90 mg). There was closed positive correlation between the iron content of potato tubers and the amount of precipitation in July (r=0.521).

The average iron content in the 3 year of the experiment was 66.13 mg without irrigation and 66.02 mg under irrigation. Irrigation did not influenced the iron content of potato considerably in the average of the years of the experiment ($LSD_{5\%}$=7.30 mg).

The iron content changed differently during the examination, relations and differences between varieties could not be established.

The average manganese content of potato tubers ranged between 5-6 mg. There was not significant difeerence between the manganese content of the varieties in the average of the 3 year of the experiment ($LSD_{5\%}$=2.63 mg).

The manganese content in the average of the 3 year of the experiment was 5.48 mg without irrigation and 5.51 mg under irrigation, irrigation did not influenced the average manganese content ($LSD_{5\%}$=0.48 mg).

There was negative correlation in every year between the manganese content and the the dry matter content. There was positive correlation between the manganese content and the phosphorous-, and in addition the magnesium content.

The average boron content of potato tubers ranged between 4.55-6.10 mg during the experiment.

There wasn't significant difference between the boron content of the varieties. The difference between the boron content of the varieties was not significant in the average of the 3 years of the experiment as well (LSD5%=1.80 mg). Irrigation did not influence the boron content during the experiment.

In the average of the 3 years of the experiment the boron content was 5.60 mg under non-irrigated and 5.42 mg under irrigated cultivation ($LSD_{5\%}$=0.41 mg).

There was positive correlation between the boron and the calcium content in every year.

There was significant difference between the copper content of the varieties in every year. The copper content of Lorett, Kuroda, Desirée and Kondor varieties were high, the copper content of Hópehely was low in every year during the experiment.

In the average of the years of the experiment the copper content of Lorett variety (6.60 mg) was higher than the copper content of Hópehely (3.62 mg) and Kánkán (3.92 mg) varieties.

There was closed positive correlation between the boron content of the potato tubers and the amount of precipitation during the breeding season (r=0.655**) and between the amount of precipitation in July (0,337**).

The copper content in the average of the 3 years of the experiment was 5.17 mg without irrigation and 5.04 mg under irrigation. Irrigation did not influenced the copper content in the average of the years of the experiment as well ($LSD_{5\%}$=0.28 mg).

There was positive correlation between the copper content and the phosphorous content. In 2005 and 2006 there was positive correlation between the copper content and the dry matter content. In 2004 and 2006 there was positive correlation between the copper content and the magnesium content.

The average zinc content of potato tubers changed between 10.80 and 13.04 mg.

The zinc content of the varieties was variable during the experiment. In the average of the 3 years of the experiment the zinc content was 11.60

mg under non-irrigated and 11.19 mg under irrigated cultivations, but the difference between the irrigated and non-irrigated replications was not significant. There was not significant difference between the zinc content of the varieties as well.

In 2004 and 2006 there was positive correlation between the zinc content and the magnesium content.

CONCLUSIONS

Effect of irrigation on the mineral content of different potato varieties were examined under irrigated and non-irrigated circumstances. There is a relation between the contents of certain elements of potato.

There was a positive correlation between the magnesium and potassium (2004: r=0.628**, 2005: 0.564**, 2006: 0.604**) and the sulphur (-2004: 0.378*, 2005: 0.457**, 2006: 0.484**) and manganese content (2004: 0.384*, 2005: 0.546**, 2006: 0.631**) of the tubers as well.

There was a positive correlation between the boron- and the calcium content (2004: 0.398*, 2005: 0.490*, 2006: 0.386*) and between the iron- and sodium content every year during the experiment (2004: 0.409*. 2005: 0.346*, 2006: 0.634**).

There was a positive correlation between the phosphorous and manganese (2004: 0,407*, 2005: 0,635**, 2006: 0,635**) and the copper content (2004: 0.509**, 2005: 0.776**, 2006: 0.776**) as well.

Year has effect on certain mineral contents.

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