INFLUENCE OF LOCALITY AND WAY OF GROWING ON THE NITRATE CONTENT IN POTATO TUBERS*

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In the period from 1995 to 1997 years field trials influence of soil and environmental conditions of localities with different above sea levels, variety, year and ecological way of cultivation on nitrate content (in seven varieties) in fresh potato tubers was investigated. In three year's trials significantly higher nitrate content (145.1 mg $NO_3^-.kg^{-1}$) in potato tubers from drier and warmer lower regions was determined in comparison with traditional potato localities of the Czech Republic of higher regions (114.4 mg $NO_3^-.kg^{-1}$). There were found highly significant differences of nitrate contents among analysed varieties. In seven analysed varieties we have determined the highest nitrate content in the variety Impala (204.5 mg $NO_3^-.kg^{-1}$), the lowest in Agria variety (70.3 mg $NO_3^-.kg^{-1}$). The greatest influence on nitrate content had the year period. In a given year we have found these average contents: 1995 – 168.9 mg, 1996 – 107.0 mg, 1997 – 112.4 mg $NO_3^-.kg^{-1}$. In ecological way of cultivation in all investigated years of cultivation decrease of nitrate content against results obtained for potatoes cultivated in conventional way that have not exceeded levels of statistical significance (by 15.5%, 6.5% and 8%) was observed.

potato; nitrates; locality; ecological cultivation; variety; year of cultivation

INTRODUCTION

Potato tubers contain, besides compounds important in human nutrition, also other compounds that could represent health risk in certain amounts. This is the reason why for many years attention has been focused on nitrate content in potato tubers (Serio et al., 2004) with the aim to reduce nitrate levels (Djennane et al., 2002, 2004). Nitrate content in potato tubers are in many countries limited. In the Czech Republic it is restricted by intimation of the Ministry of Health since the year 1997 that has adapted previously valid limit (that has been too restrictive) to requirements of EU countries on today's level 300 mg $NO_3^-.kg^{-1}$ and in early potatoes (until 15. 7.) 500 mg $NO_3^-.kg^{-1}$ of fresh potato tubers.

Nitrate content in tubers is influenced besides nitrogen fertilisation also in great deal by factors affected by weather and locality conditions (Frydecka-Mazurczyk, Zgórska, 2000). Knowledge about particular influence of individual factors is not unambiguous. Míča et al. (1991) have drawn conclusions that basic presumption of lower nitrate content in tubers is sufficient precipitation amounts (500 mm precipitation during the period of vegetation should insure their sublimited content in tubers). It depends also on distribution of precipitation during vegetation and on other factors. E.g. cool weather, little counts of sunny days and rich precipitation decrease in photosynthetic activity and eventuate in nitrate accumulation in their consequence. Augustin et al. (1977) in peeled potato tubers cultivated at 65% and 85% soil moisture level during period of vegetation found the decrease of nitrate nitrogen on higher soil moisture level. With high nitrate concentration on the tuber surface, up to 40% of total tuber nitrate content can be taken up through the tuber skin (Lin et al. (2004). Frydecka-Mazurczyk, Zgórska (1996) determined that the increase of nitrate content could be caused by the insufficient precipitation and high temperature, but also by the excess of precipitation and low temperature. Frydecka-Mazurczyk, Zgórska (2000) in other report determined that nitrate content is significantly affected by the maturity of potato tubers. Green non-maturated tubers harvested in August have their contents higher in comparison with fully ripened tubers harvested in September. Significant influence of year of cultivation demonstrated in trials with five varieties Cieślik (1994). Comparative study of nitrate contents in potato tubers cultivated by conventional and ecological way generally confirm tendency to lesser nitrate contents in potatoes cultivated ecologically or even significant differences (Woese et al., 1995; Prugar, 2000; Guziur et al., 2000).

The aim of this work was to compare nitrate content in potatoes cultivated in different soil climate conditions of traditional potato growing regions in CR and lower regions where in the 1990s substantially increased areas cultivated with potatoes designated for human nutrition. Other items to solve were to determine influence of ecological way of cultivation, to determine varietal differences and influence of the given year.

MATERIAL AND METHODS

In the years 1995–1997 in the field trials on twelve localities in CR potatoes of Impala, Karin, Korela,

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Table 1. Characteristics of weather in vegetation period in the years of cultivation

Year	Region	Average temperature (°C)			Sum of precipitation (mm)		
		August	September	April–September	August	September	April–September
1995	LR	18.92	13.57	15.63	90.6	82.4	439.9
	HR	16.15	11.80	13.42	100.2	113.0	527.7
	Aver.	17.53	12.68	14.53	95.4	97.7	483.8
1996	LR	18.23	11.10	14.57	73.3	53.1	463.5
	HR	16.12	9.02	12.40	97.1	69.0	490.9
	Aver.	17.18	10.06	13.48	85.2	61.1	477.2
1997	LR	19.90	13.98	15.02	46.9	29.3	391.8
	HR	18.02	12.70	13.12	33.6	25.6	487.9
	Aver.	18.96	13.34	14.07	40.2	27.3	439.8
Long-term average	LR	18.03	14.28	15.15	71.5	45.4	360.1
	HR	15.83	11.23	12.73	83.2	52.2	424.7
	Aver.	16.93	12.76	13.94	77.3	48.8	392.4

LR – lower regions (average of 6 localities), HR – higher regions (average of 6 localities), Aver. – average of all 12 localities

Rosella, Santé and Ornella varieties were cultivated after unified ways of planting according to the Central Institute for Supervising and Testing in Agriculture of the Czech Republic. Six localities were situated in lower, warmer and drier regions with fertile predominantly loam soils (Orthic Luvisol and black Luvic Chernozem prevailed) and in this contribution they are indicated with the common term "lower regions". Other six localities were situated in higher, cooler and more humid regions with less fertile predominantly sandy loam soils (Cambisol prevails) and it represents traditional potato growing regions in the Czech Republic. In our contribution we have indicated them as "higher regions". The main mean weather parameters during the tested period are given in Table 1. On two localities there was besides conventional way of potato cultivation included into the trials other variant – growing with ecological way of cultivation without using chemical protection and industrial fertilisers. Nitrate content was determined in tubers from all localities (in all seven varieties) after the harvest in the given years. For nitrate content tubers were analysed with ion selective electrode – ISE (Nitrate XQ-1 Orion, Boston) after Davídek et al. (1977).

RESULTS AND DISCUSSION

From investigated factors (locality, variety, and year of cultivation) the locality had the lowest but significant influence on nitrate content in tubers (Table 2). Potatoes cultivated in lower regions contained in all three years more nitrates than potatoes cultivated in higher regions (Fig. 1). Conclusive effect on higher nitrate content in potatoes from lower regions had evidently significantly lower total sums of precipitation amounts and higher average temperatures in vegetation period (Table 1), especially in periods critical for plant and tuber growth in these regions in comparison with higher regions. In these higher situated regions stresses caused with dryness have slightly damaged process of photosynthesis and restricted using of nitrogen by plant. Sum of precipitation in vegetation periods in the years 1995, 1996 a 1997 in lower altitudes reached 83.3%, 94.4% and 80.4% of value in higher altitudes.

Table 2. Calculated *F*-values for three years' results of nitrate content

Source of variability	Regions	Varieties	Years
F-values	26.113	33.265	49.004
Significance	**	**	**

** statistically highly significant difference ($P < 0.01$)

Our results confirm information of Frydecka-Mazurczyk, Zgórska (2000), Cieślik (1994), Míča et al. (1991) and Augustin et al. (1977). Higher nitrate content in the localities situated in lower regions could bear on soil conditions. On Orthic Luvisol and Luvic Chernozem with higher soil fertility and biological efficiency in connection with higher average temperatures in lower regions are apparently in consequence of mineralisation accumulating more nitrates (higher supply in soil solution influences their cumulating by plants) in comparison with soils of higher regions. Similar information gave also Prugar (1992) who mentioned that the higher soil fertility had higher potential ability of plant to accumulate nitrates.

Significant influence on nitrate content had the variety (Fig. 2). From seven used varieties in average of three years nitrates accumulated at the greatest deal Impala variety (very early) and the Karin variety (early). These two varieties have differed from others significantly in nitrate content, among them there were found significant differences. The group with average nitrate content within investigated varieties represented the Korela, Rosella and Santé varieties (all semi-early). The lowest values has demonstrated the Ornella variety (semilate)

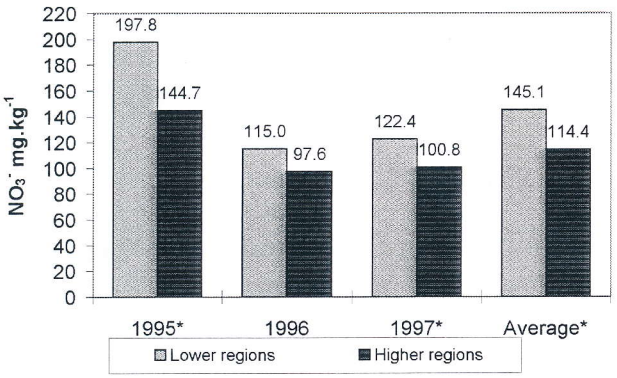

Fig. 1. Nitrate content in fresh mass of tubers (NO_3^- mg.kg^{-1}) affected by the conditions of habitat (average of 7 varieties from 6 localities of every region). $D_{min\ p\ 0.05}$ = 25.16 (1995); 18.32 (1996); 15.78 (1997) and 11.37 (average)

* significant difference between regions for P = 0.05

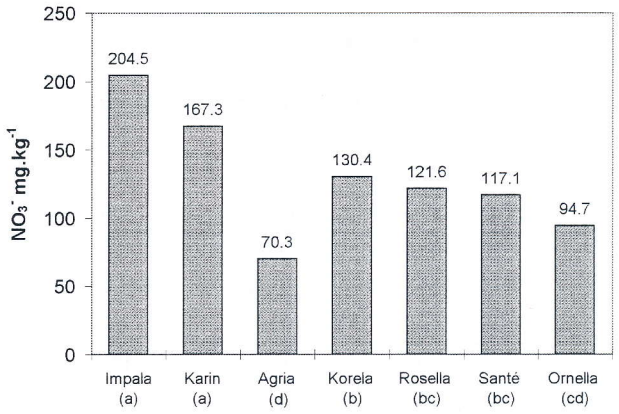

Fig. 2. Nitrate content in fresh mass of tubers (NO_3^- mg.kg^{-1}) affected by variety (average of 3 years and 12 localities). $D_{min\ p\ 0.05}$ = 38.15. Differences between varieties marked with the same letters are not significant for P = 0.05

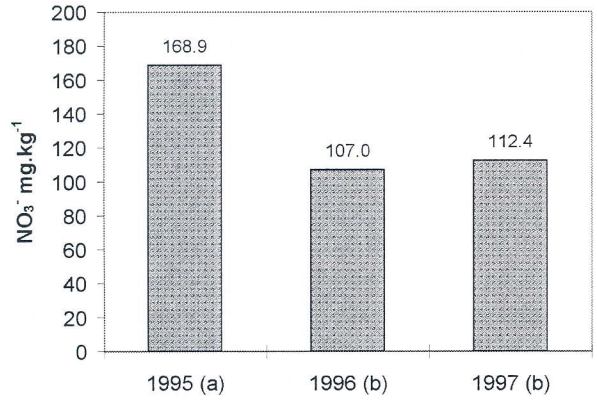

Fig. 3. Nitrate content in fresh mass of tubers (NO_3^- mg.kg^{-1}) affected by the year of cultivation (average of 7 varieties from 12 localities). $D_{min\ p\ 0.05}$ = 16.67. Differences between years marked with the same letters are not significant for P = 0.05.

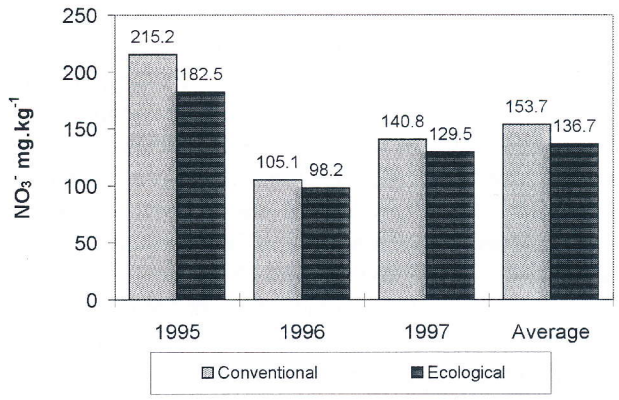

Fig. 4. Nitrate content in fresh mass of tubers (NO_3^- mg.kg^{-1}) affected by the way of cultivation (average of 6 varieties and 2 localities). $D_{min\ p\ 0.05}$ = 37.65 (1995); 27.30 (1996); 29.43 (1997) and 27.37 (average)

and on the first place Agria (early) showing only 34% of nitrate content in the Impala variety. Relationship of variety to nitrate content showed that varieties with shorter vegetation period inclined to higher accumulation of nitrates in comparison with varieties with longer vegetation period. It bears on physiology of growth, when the plant needs certain time and conditions to the conversion of nitrates – their reduction to NH_3 and incorporation to proteins. Determined varietal differences in nitrate content correspond the results that were already published earlier (Frydecka-Mazurczyk, Zgórska, 2000; Hamouz, 1991; Jůzl, 1993).

From investigated factors the most apparent influence on nitrate content had the year of cultivation (Table 2). The year 1995 with the highest precipitation sum in vegetation period in average from all experimental localities (123% of normal value) from all investigated years had a significant difference in high nitrate content from the both following years (Fig. 3). Regarding above-average precipitation in vegetation in the year 1995 this result is surprising because according to the authors mentioned above (Frydecka-Mazurczyk, Zgórska, 2000; Cieślik, 1994; Míča, 1991) just enough precipitation is a basic presumption of low accumulation of nitrates in tubers. Our results were apparently influenced significantly by uneven distribution of precipitation amounts during vegetation in the year 1995, especially with their extraordinary high sums at the end of period of vegetation (in September 202.2% of normal value from all experimental localities in average). Plants had too long vegetation period, badly ripened and nitrates could not be incorporated into amino acids and proteins. High nitrate contents in immature tubers are referred, e.g. by Jůzl (1993), Hamouz (1991) and Cieślik (1994). On some localities at the end of vegetation period occurred extraordinary high amounts of precipitation, bellow-normal temperatures and low number of sunny days. These factors have probably caused lower photosynthetic activity and nitrate accumulation (in accordance with results obtained by Míča et al.,

1991; Frydecka-Mazurczyk, Zgórska, 1996). Valid limit 300 mg NO_3^-. kg^{-1} for nitrate content in tubers was not in the years 1996 and 1997 exceeded in any case. In the year 1995 it was over crossed in four from 88 samples.

In the potatoes cultivated in ecological way there could be observed in all investigated years the trend of lower nitrate content in tubers as compared with potatoes cultivated in conventional way (Fig. 4), but the results obtained were not significant. Determined trend is in accordance with the published data that predominantly confirm tendency (or significant differences) to lesser nitrate content in the tubers of ecologically cultivated potatoes (Woese et al., 1995; Prugar, 2000; Guziur et al., 2000) relatively considerable difference in nitrate contents between ways of cultivation (near bellow measure of significance) in the year 1995, but in two following years differences were much lower. It is apparently in connection with premature termination of vegetation with late blight (*Phytophtora infestans* Mont.) in this chemically not treated variant cultivated in ecological way. This happened in 1996 and 1997 at the stage of full vegetation when the tubers were immature and nitrates were incorporated into other compounds only in lesser extent. Also Böhm (1999) and Molgaard et al. (1999) bring premature necrosis of potato haulm in consequence of the attack with late blight as the cause of increased nitrate content of ecologically cultivated potatoes.

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Vliv stanoviště a způsobu pěstování na obsah dusičnanů v hlízách brambor.

Scientia Agric. Bohem., *36*, 2005: 10–14.

V práci byl sledován obsah dusičnanů v hlízách brambor vypěstovaných v rozdílných půdně-klimatických podmínkách tradičních bramborářských oblastí ČR (vyšší polohy) a nižších poloh, kde došlo v 90. letech ke značnému nárůstu ploch konzumních brambor. Dále byl sledován vliv ekologického způsobu pěstování, vliv ročníku a odrůdové rozdíly. Přesné polní pokusy se sedmi odrůdami se uskutečnily v letech 1995 až 1997 na šesti stanovištích každé oblasti blíže charakterizovaných v práci autorů Hamouz et al. (1999). Rozbory čerstvé hmoty hlíz po sklizni byly u dusičnanů provedeny iontoselektivní elektrodou. Byl zjištěn průkazně vyšší obsah dusičnanů u brambor z nižších poloh (obr. 1). To souvisí jednak s vyšší úrodností půd v nižších polohách (Prugar, 1992), jednak s nižšími dešťovými srážkami v kritických obdobích vegetace pro růst rostlin a hlíz v této oblasti proti vyšším polohám, kde stresy suchem narušily proces fotosyntézy a zpomalily zabudování dusičnanů do bílkovin (Míča et al., 1991; Frydecka-Mazurczyk, Zgórska, 2000). Průkazný vliv na obsah dusičnanů měla rovněž odrůda. S výjimkou odrůdy Agria obsah dusičnanů vcelku koresponduje s raností odrůd (obr. 2). Ze sledovaných faktorů měl nejvyšší vliv na obsah dusičnanů ročník (obr. 3) – mimořádně vysoké úhrny srážek na konci vegetace (v září v průměru stanovišť 202,2 % normálu), podnormální teploty a malá četnost slunečních dnů na některých stanovištích v roce 1995 se projevily na snížené fotosyntetické aktivitě a hromadění dusičnanů (Míča et al., 1991; Frydecka-Mazurczyk, Zgórska, 2000). U některých porostů se projevilo i horší vyzrávání. U brambor z ekologického pěstování se projevil ve všech letech trend nižšího obsahu dusičnanů oproti konvenčnímu, ale rozdíly byly neprůkazné (obr. 4).

brambory; dusičnany; stanoviště; ekologické pěstování; odrůda; ročník

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