Effect of Selected Factors on the Content of Ascorbic Acid in Potato Tubers

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Abstract

In precise field trials in the Czech Republic the effect of conditions of locality, variety and fertilization on ascorbic acid content (AA) in potato tubers was investigated. From four localities was determined the highest AA content at the locality with the highest temperature average values during both experimental years (by 6.7 to 11.5% in comparison to other localities). Likewise significant was the effect of variety, Marabel variety with the highest AA content (207.2 mg/kg FM) exceeded other seven varieties by 15–49%. Negative effect on AA content in tubers has shown increased intensity of N fertilization. Contrary, favourable effect was determined at increased levels of K and Mg fertilization.

Key words: ascorbic acid, potatoes, locality, variety, fertilization

Introduction

Ascorbic acid (AA) contained in potato tubers possesses significant physiological efficiency, for example as antiscorbutic factor and important natural antioxidant (Lachman et al. 2000). In two recent surveys of potato genotypes, AA concentrations varied between 18 to 36 mg in six European varieties and 27 breeding lines (Dale et al. 2003). Significant effect on AA content has genotype, which in field experiment with 26 German varieties demonstrated Weber and Putz (1999). Pawelzik et al. (1999) investigated the effect of locality, which influenced AA content in two varieties of four. Nowacki et al. (2000) investigated in twelve years running experiments the effect of the sum of precipitation on the AA content. They recorded in dry years higher AA content (22.1 mg/100 g FM) than in wet years (18.9 mg/100g FM). Negative effect of N fertilization on the AA content describe Nowacki et al. 2000). However Lin et al. (2004) discovered only a little effect of nitrogen fertilization on the AA content, only high doses of nitrogen that lead to the yield depression significantly reduced AA content. Two sources of K fertilizer, KCl and K2SO4 significantly increased the AA content in the experiments carried out by Mondy and Munshi (1993). Nowacki et al. (2000) also determined favourable effect of K fertilization in the form K2SO4 on the AA content. The aim of this study was to examine the influence of locality, genotype and fertilization with inorganic fertilizers (N, P, K) on the AA content in potato tubers.

Material and methods

In precise field trials in the years 2004 and 2005 on the four localities in Czech Republic (Přerov nad Labem, Praha – Suchdol, Lípa, Stachy) with different altitude Impala, Karin, Ditta and Saturna varieties were cultivated by unified way according to the standards common agricultural engineering, on the locality Lípa in addition Agria, Asterix, Magda and Marabel varieties. Basic characteristic of various localities is described in Table 1. Trials were based in four parallels in 75 x 30 cm spacing, area of parcel 3 m (4 rows) x 7.2 m. The second trial was based on the Valečov locality (Table 1), where the influence of different fertilization levels with N, P, K, Mg nutrients was investigated. The trial was made with Ditta and Karin varieties, agricultural engineering was (in exception of inorganic fertilizers) the same as in the first experiment. Fertilization variants are mention on figure 3.
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After the harvest in the stage of physiological maturity the samples of tubers from parallels of every experiment were sampled to laboratory analyses, which were performed at the Department of Chemistry of the Czech University of Agriculture in Prague. AA content was determined polarographically on the micropolarograph Eko - Tribo Polarosenor (CR). Obtained results were statistically run by the method of variance analysis (ANOVA) with more detailed evaluation by means of Fisher test in computer programme SAS (version 8.02) at the level of significance \( P = 0.05 \).

| Table 1. Characterization of experimental localities |
|---|---|---|---|
| Locality | Level above sea (m) | Av. annual temper. (°C) | Annual sum of precipitation (mm) | Soil type | Soil category |
| Přerov nad Labem | 178 | 8.8 | 622 | TBS | sl - l |
| Praha-Suchdol | 286 | 8.2 | 510 | TBS | l |
| Lípa | 505 | 7.7 | 632 | PGAC | sl |
| Stachy | 860 | 6.3 | 755 | BPS | ls |
| Valečov | 460 | 6.9 | 649 | PGAC | sl - l |

Soil Categories: TBS – typical brown soil, PGAC – pseudogleyic acid cambisol (brown gleysol), BPS - cryptopodzol (brown podzolic soil)  
Soil Texture Class Groupings: sl – sandy loamy, ls – loamy sandy, l - loamy

Results and Discussion

Effect of locality

Among four experimental localities in the average of both years the highest AA content on the Přerov n. L. locality (Figure 1) was significantly determined. On other localities lower AA levels in tubers in average of both years were recorded (by 6.7% up to 11.5%). To the highest AA content in Přerov n. L. contributed the warmest climate with lower precipitations (Table 1) which correlated well also with weather during vegetation period of experimental years. Our result is in accordance with conclusions resulting from experiments of Sawicka and Mikos-Bielak (1995), where high air temperatures in vegetation favourably stimulated vitamin C accumulation in the tubers of very early potato varieties. Also Jabłońska-Ceglarek and Wadas (2005) came to the same conclusion on the basis six years running experiment. Simultaneously with climatic conditions the effect of sandy loamy brown soil on the Přerov n. L. locality could come across (significant difference compared to Suchdol locality with similar climatic conditions, but on the loamy soil). Hereafter Pawelzik et al. (1999) documented the effect of locality on the AA content.

Effect of variety

The AA content in tubers of various varieties on Lípa locality ranged from 136.3 to 211.8 mg/kg FM and was demonstrably affected by variety. In average of both years (Figure 2) the highest AA content (207.2 mg/kg FM) was found in Marabel variety, which significantly exceeded Saturna, Magda, Impala, Agria, Asterix and Ditta varieties by 15 to 49%. The second place joined Karin variety, which significantly exceeded the same varieties as Marabel variety except Ditta variety (the third in the order of sequence). Agria variety was the other one that reached higher AA content than average value of investigated varieties. AA concentration in potatoes obtained from our experiments conforms to the results published by other authors (Dale et al. 2003). Our results also confirmed significant effect of variety on AA content that was described by Weber and Putz (1999) and Pawelzik et al. (1999).
Effect of mineral fertilization

AA content was conclusively affected by different level of mineral fertilization (Figure 3). Positive effect on AA content had enhancement of potassium dose to 166 kg K/ha at contemporary increase of magnesium dose to 60 kg Mg/ha (variant 3). In the year 2004 it was only tendency, but in the year 2005 and in average of both years the result was confirmative. AA content increase in variant 3 in the year 2005 was 8.7% and in average of the years 2004-2005 6.2% compared to control variant 2. Our result about the favourable effect of potassium fertilization on the AA content is in accordance with conclusions of Nowacki et al. (2000) and Mondy and Munshi (1993). Hereafter from our results is apparent negative effect of enhanced level of nitrogen fertilization 180 kg N/ha (variant 4) on the AA content. It decreased in the year 2004 by 4.5% and in the year 2005 by 7.8% compared with control variant 2 and in average of both years was statistically significant (Figure 3). Nowacki et al. conclusion was thus confirmed (2000).
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Conclusions

AA content in tubers of 8 cultivars ranged between 141.60 - 211.8 mg/kg FW and was confirmatively influenced by cultivar genotype. Statistically confirmative influence on AA content had also site conditions – the highest AA content was in both years found at locality Přerov nad Labem in Labe river lowland with the highest average year temperature (8.8 °C) and with lighter sandy loamy soil. Regarding mineral fertilization positive influence on AA content was found in kalium and magnesium dose escalation on 200 kg of K₂O and 100kg of MgO/ha, respectively. Negative effect had increasement of nitrogen fertilization up to 180 kg N/ha.

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References


