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Impact of boron foliar fertilization on annual fluctuation of B in sweet cherry leaves and fruit quality

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Summary: The goal of the study was to examine response of sweet cherries (*Prunus avium* L.) to boron (B) fertilization. The experiment was conducted during 2005–2007 in West Hungary on mature cv. 'Germersdorfi 3' grafted on *Prunus mahaleb* rootstock.
Sweet cherry trees planted on a calcareous chernozem soil. Trees were foliar-fertilized with B. Foliar B sprays were performed: (1) in the spring, at the stage of white bud, beginning of flowering (B_1), and (2) repeated 5 weeks after full bloom (B_2). In each of spring spray treatments, B was applied at a rate of 0.15 kg ha^{-1}. Trees untreated with B served as a control.
The results showed that B fertilization had effect on B concentration in leaf tissues, mostly after ripening. B was present significantly higher amount in leaf in treated samples after ripening.
Mean fruit weight was slightly increased by B fertilization. Fruit sensitivity to cracking was not influenced by B fertilization. Nevertheless, from our data it can be conclude that the sensitivity of fruit to cracking is improved when the fruit is riper, the fruit density and fruit weight are higher. The soluble solids varied between 15.0 and 15.9% according to the treatments. Our results for the monosaccharides investigated varied between 5.1 and 7.2 as glucose and fructose as well. Galactose and sucrose was detected very small amount in the unprocessed cherries. Applied B treatments increased sugar contents but decreased organic acid contents in sweet cherry fruits.
It is concluded that under conditions of this experiment, B fertilization can be recommended in sweet cherry culture to improve fruit quality and their appearance.

Key words: sweet cherry, foliar nutrition, boron fertilization, fruit quality

Introduction

Boron is an essential micronutrient in plants that is often deficient in most soils because most of the boron in the soil is adsorbed to clay minerals, hydrous metal oxides, and organic matter in soils. In addition, boron can be co-precipitated with calcium carbonate making it unavailable to the roots. Moreover the B uptake is hindered by very wet or very dry soils, increased leaching and cold soil temperatures.

Boron deficiency trees exhibit little shoot growth. Some buds of B-deficient plants may fail to open in the spring, whereas others may open and then shrivel and die. Leaves are distorted in shape, with irregular serration and may cup or roll in a downward direction. Splitting of the bark may occur.

The major role of B in fruit trees involves fruit set (*Faust*, 1989). Apple, pear and cherry flowers are very high in B. The B needed in the flower is transported mainly from the reserves in the adjacent branches and not from the roots during the development flower. It is essential for reproduction, aids in the formation of pollen germination and pollen tube growth. Boron aids in the metabolism of hormones and in the translocation of calcium, sugars and growth regulators, required for protein synthesis. In addition B is important for early growth, flowering and fruit set (*Kamali & Childers*, 1970), maintains balance between sugar and starch, aids in auxin regulation and of course it is necessary for cell division and differentiation, and root tip development.

Therefore, the close attention to B levels is important because both low and high concentrations cause poor fruit quality. Low B results in short storage life with the fruit having a higher susceptibly to storage breakdown and fruit deformities. High B results in a higher incidence of internal disorders such as watercore and internal breakdown.

However the role of Boron (B) is well-known in the plant nutrition, especially fruit nutrition, there are very little information about its application and use in Hungarian orchards.

Therefore, the aim of our experiment was to study the triennial effect of foliar boron application on annual fluctuation of B in sweet cherry leaves and fruit quality.

Material and methods

The study was conducted during 2005–2007 in West Hungary on cv. 'Germersdorfi 3' grafted on *Prunus mahaleb* rootstock. Trees were planted in the spring of 1999. Trees

spaced 7×5 m, and growing in a calcareous chernozem soil at Siófok in West-Hungary. Orchard was not irrigated in 2005, 2006 and 2007. For the purpose of the experiment, 3×10 trees were randomly selected from a population of trees with uniform characteristics.

As the optimal period for B sprays is the beginning of flowering up to petal fall sprayings were applied in this period *(Table 1)*.

For spraying, Solubor (Disodium Octaborate Tetrahydrate – 20.9% B) was applied.

Table 1 Applied foliar fertilization system

Applied nutrient	Dose (kg ha^{-1})	Time of applications	Code of treatment
Control	–	–	C
B as $Na_2B_8O_{13}{\cdot}4H_2O$	0.15	at full bloom 5 weeks after full bloom	B_1 B_2

Soil sampling and preparation

Two soil samples were collected from three layers (0–20, 20–40 and 40–60 cm) of each treatment by using manual soil sampling equipment following the Hungarian sampling guidelines and according to *Nagy* et al. (2006). Sampling was performed before treatments, at the beginning of the vegetation period in March 2005. Sample preparation of the soil samples was performed according to Hungarian guideline (*MSZ 20135:1999*). The following parameters were measured: pH, K_A, content of humus and AL soluble P and K according to Hungarian guidelines.

Leaf and fruit sampling and preparation

Leaf samples were taken, from May to September (20, 35, 100 (at ripening) and 170 days after full blooming, respectively) from 2005 to 2007, annually according to international conception and Hungarian sampling guidelines (Stiles and Reid 1966; *MI-08 0468-81*). Healthy, fully developed leaves were taken from the mid-third portion of extension shoots current year were collected.

Leaf samples were washed with distilled water to remove dust and possible remains of pesticide, than dried outdoors in an airy place for a week. After drying samples in a well-ventilated drying oven for 6 hrs at 40 C, the whole sampled material was finely grounded and homogenized. Samples were then stored in paper bags in a dark and dry place until use.

Leaves were taken from all trees. For leaf boron analysis 1 g plant sample was ashed in a muffle furnace at 450 °C. Ash was dissolved in 5 ml of a 1M HCl at room temperature, mixed, and measured by photometric method (Azomethin-H method).

Fruits were collected at repining in 2007. Approximately 1 kg fruit was picked per tree. Sugars (glucose, galactose, fructose and sucrose) in fruit were determined by HPLC (AOAC Method 992. 14). Thermo Hypersil column AP-2 100×3 mm was used (eluent was $CH_3CN:H_2O$=8:2 (v/v)) and LSD (30°C, spraying pressure: 350 kPa) detector.

Examinations of fruit quality

For fruit assessments, approximately 1kg fruits per treatment were examined.

Fruit cracking (%)

It was calculated as a ratio of the number of cracked fruits and the number of total fruits.

Fruit weight (g)

It was measured with a digital analytical scale with 0.1 g punctuality.

Fruit density (1–9)

This parameter was given a number on a subjective scale from 1 to 9 (determined at 10 trees). Where, 1 means the tree without fruit and 9 means the tree fully covered fruits. It was established two weeks before harvest.

Maturity (1–9)

This parameter was given a number on a subjective scale from 1 to 9 (determined at 10 trees). Where, 1 means the unripe fruit and 9 means the totally ripe fruit. It was established two weeks before harvest.

Soluble solids and sugars

The sugars (fructose and glucose) and soluble solids (Brix) were studied at harvest in the sweet cherries (*Prunus avium* L.) cv. 'Germersdorfi 3' in 2005 and 2006. All fruit samples had been picked at the optimal ripening time. For examination 1kg fruits were performed. For study of soluble solids fruits were pressed and the obtained juice was filtered through (FILTRAK Qual. grade:132) folded filters. Soluble solids were determined in the juice by refractometer (ATAGO PAL series) at 20 °C.

Sugars (glucose, galactose, fructose and sucrose) in fruit were determined by HPLC (AOAC Method 992. 14). Thermo Hypersil column AP-2 100×3 mm was used (eluent was $CH_3CN:H_2O$=8:2 (v/v)) and LSD (30°C, spraying pressure: 350 kPa) detector.

Organic acids and vitamin C

Organic acids (citric, malic and fumaric) in fruit were determined by HPLC according to *García-Alonso* et al., 2006. For determination Hypersil BDS C8, (250×4.6 mm, 5 µ) column was used (eluent was 0,2 M K_3PO_4:MeOH=9:1 (v/v)) and UV detector with wavelength at 254 nm for identification.

Vitamin C in fruit was determined by HPLC also. For determination Spherisorb ODS C18 (15x4,6, 5 µm) column was used (eluent was: 0.01 %-os K_2SO_4 (pH=2.6); flow rate was: 1 ml/min) and UV-VID DAD detector with wavelength at 245 nm for identification.

Results and discussions

Soil analysis

The orchard soil type is calcareous chernozem soil. The upper layer of soil (0–60 cm) contained 1.7% humus, 178 mg/kg and 372 mg/kg AL-soluble P and K. The plasticity index according to Arany (K_A) was 39. According to our results the soil is slightly alkaline (pH(H_2O)=7.65) loamy soil and calcareous in deeper layers. According to our data soil N-supply was weak, soil P-supply was medium and soil K-supply was adequate for growing.

Leaf analysis

Boron concentration was varied between 35 and 65 mg/kg in leaves, during examined vegetation period. It continuously increased during examined period in every treatment till ripening. Then, in the control, it significantly decreased while in B treatments its amount increased continuously (*Figure 1*). So although shoot leaves from all treatments collected in summer had similar boron concentrations, but B was present in different content in leaf tissues late (after ripening) in the season.

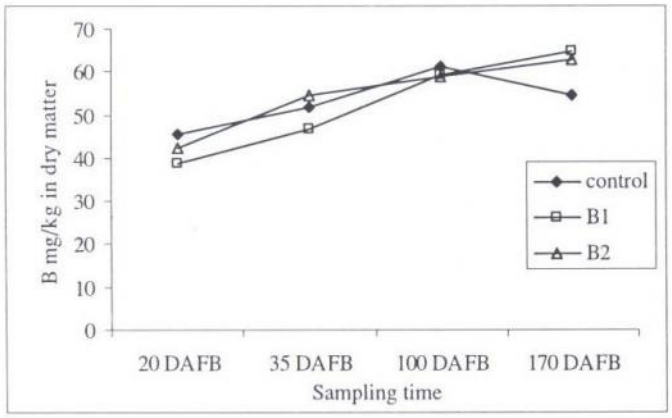

Figure 1 Effect of applied foliar treatments on annual fluctuation of B in leaves

This effect is very important for the next year´s growth. Because, the higher foliar B content plays efficient role in transport processes from the leaves into storage tissues for the next year´s growth. Moreover, we conclude that leaf B after harvest is translocated to above-ground storage organs before leaf fall and is then used the following season.

Based on the data of ripening, the leaf B values varied between 59 and 61.5. In all treatments, these values were higher than the optimal range (*Mills & Jones*, 1986; *Papp*, 2004). Obtained results can be explained by the soil properties and additional boron application.

Obtained results confirmed that earlier findings that timing of B maintenance sprays is not critical for cherry trees if the trees already contain adequate amounts of B and do not show visual evidence of B insufficiency (*Peryea*, 1994; *Peryea* et al., 2003).

Quality factors and fruit analysis

Some investigated fruit quality factors are represented in *Figure 2*.

Fruit sensitivity to cracking was influenced differently by B fertilization. B_1 treatment decreased, while B_2 increased the number of cracked fruits.

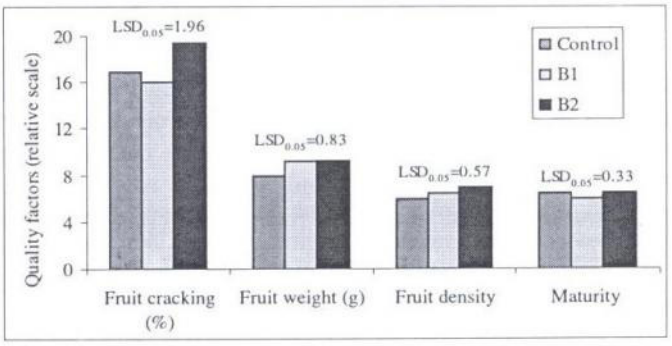

Figure 2 Effect of applied foliar treatments on some quality factords

Mean fruit weight was significantly increased by both B fertilizations.

Fruit density was increased applying foliar boron treatments, but only the B_2 treatment had significant effect on it.

Maturity was not affected by boron treatments. The lowest value was founded in the B_1 treatment and there was not statistical difference between B_2 treatment and control (*Figure 2*).

From our data it can be conclude that the sensitivity of fruit to cracking is improved when the fruit is riper, the fruit density and fruit weight are higher.

The soluble solids varied between 15.0 and 15.9% according to the treatments. Our results are similar to those reviewed by *Kaack* et al. (1996) and *Predieri* et al. (2004). Obtained results were pointed out that B applications influenced the soluble solids content of fruit similarly to those obtained by *Wojcik*, 2006. Result of B_1 treatment may be explained by the lower value of maturity. Moreover the soluble solids content is connection with maturity and fruit weight as *Blažková* et al. (2002) reported.

Our results for the mono- and disaccharides investigated are comparable to those reviewed by *Wrolstad &*

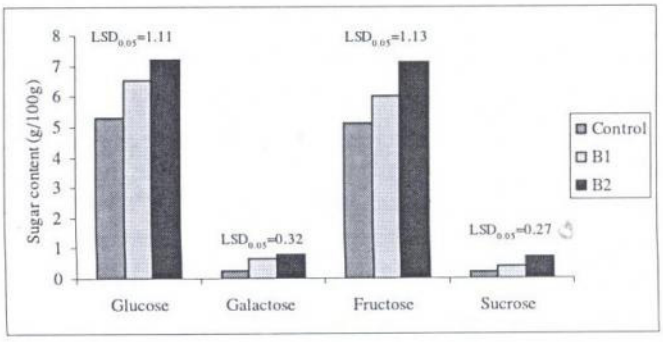

Figure 3 Effect of applied foliar treatments on contents of sugars (g/100g of fresh weight)

Schallenberger (1981), *Gardiner* et al. (1993) *Wills* et al. (1987) and *Dolenc & Štampar* (1998).

Nevertheless, *Girard & Kopp* (1998) pointed out that major sugars and organic acid constituents varied widely among sweet cherry cultivars.

Galactose and sucrose was detected very small amount in the unprocessed cherries, which is consistent with the findings of *Wrolstad & Schallenberger* (1981) who reported the absence of sucrose in some cultivars (e.g. cherries) and only low concentrations in others. No attempt was made to inactivate invertase in the unprocessed cherries as it is unlikely that this would be done in a commercial situation.

Furthermore, our results confirmed those earlier results as the content of glucose and fructose is present in approximately equal amounts in most nectar (*Van Handel* et al. (1972)).

It is concluded that under conditions of this experiment, B fertilization can be recommended in sweet cherry culture to improve fruit quality and their appearance.

Acids content of fruit

The contents of citric, malic and fumaric acid are presented in *Table 2*. Our results for the organic acids were similar to those reviewed by *Girard & Kopp* (1998) who described that malic acid varied widely (502.7–948.3 mg/100 g of fresh weight) among cultivars. Malic acid was present in cherry fruits in higher contents than other organic acids. Amount of it was approximately nine times more than the amount of citric acid. The content of fumaric acid was negligible compared to citric and mostly malic acid.

On the contrary of analysis of sugars, the boron treatments had a negative effect on investigated organic acids. Repeated boron application caused further decrement of organic acids in cherry fruit. From results it seems that the content of sugars was improved but the content of organic acids of cherry fruit was slightly decreased applying boron foliar nutrition.

B_1 treatment increased significantly the amount of vitamin C while its amount was not increased when boron was applied twice compared to the control.

From results it seems that the content of sugars was improved but the content of organic acids of cherry fruit was slightly decreased applying boron foliar nutrition.

It is concluded that under conditions of this experiment, repeated K and Ca foliar fertilization can be recommended in sweet cherry culture to improve organic acids of fruit. Moreover this effect results decrease of sugar contents.

Table 2 The content of organic acids (mg/100g fresh weight)

Treatment	Citric acid	Malic acid	Fumaric acid	Vitamin C
	mg/100g fresh weight			
C	12.20	908.40	0.05	8.00
B_1	11.20	872.40	0.01	8.40
B_2	10.50	852.90	0.01	8.00
Average	11.30	877.90	0.02	8.13
$LSD_{0.05}$	0.97	31.86	0.03	0.26

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