International Journal of Horticultural Science 2011, 17 (1–2): 45–48.
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Effect of boron nutrition on nutrient uptake and fruit quality of tart cherry in Eastern Hungary

Nagy, P. T.[1], Nyéki, J.[2], Soltész, M.[3], Szabó, T.[4] & Szabó, Z.[2]

[1]*Institute of Environmental Sciences, Faculty of Natural Resources Management and Rural Development, Károly Róbert College, Mátrai str. 36. Gyöngyös, H-3200, Hungary nagypt@karolyrobert.hu*
[2]*University of Debrecen Centre for Agricultural and Applied Economic Sciences, H-4032 Debrecen, Böszörményi út 138., Hungary*
[3]*Collage of Kecskemét, Faculty of Horticulture, H-6000 Kecskemét, Erdei Ferenc tér 1–3.*
[4]*Research and Extension Centre for Friut Growing, H-4244 Újfehértó, Vadastag 2.*

Summary: Effect of the foliar boron (B) application on nutrient uptake and fruit quality of tart cherry (*Prunus cerasus* L.) was investigated from 2008 to 2009 on mature four favourite Hungarian tart cherry cultivars like 'Oblacsinszka', 'Érdi bőtermő', 'Újfehértói fürtös' and 'Petri'. Tart cherry trees grown in Eastern Hungary (Újfehértó) on an acidic sandy soil with low B content. Trees were treated with B by foliar application (0.5% B) at full bloom and untreated with B served as a control. B sprays strongly affected on B content of inflorescences. However, B sprays had no consistent effect on summer leaf B status. In our experiment stronger year effect was observed at leaf B status than flower B status. The effectiveness of early spring boron applications are limited and mostly affected the flower B status only. Moreover, treatments had inconsistent effect on studied fruit inner parameters. Monosaccharides, vitamin C and organic acid contents of sour cherry were stronger affected by cultivars than applied treatments.

Keywords: *Prunus cerasus* L ., boron fertilization, nutrient uptake, fruit quality

Introduction

Boron (B) is an essential micronutrient in plants and among micronutrients its role is studied more frequently than others all over the world due to its advances on the fruit set and maturity (*Faust,* 1989; *Fallahi* et al., 2010). Despite of the intensive research, the role of B in plant is still least well understood of all mineral nutrients (*Mengel* et al., 2001).

Moreover, B deficiency occurs often 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 (*Gupta,* 1979; *Goldberg,* 1997). Therefore boron deficiency is occurred mostly at heavily clayed soils and sandy soils with low status of organic matter as well.

In the last few decades the boron deficiency is the most widespread of all the micronutrient deficiencies in many crop regions from tropical to temperate zones (*Shorrocks,* 1997). Moreover, where low B soils are present, stresses resulting from chilling temperature and B deficiency are likely to be present simultaneously or sequentially (*Huang* et al., 2005).

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 and 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. Earlier it has been suggested that tart cherry cracking may be related to boron nutrition but not much evidence has been presented in support of this (*Boynton,* 1966; *Wann,* 1966).

Nowadays 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 is well-known in the plant nutrition, especially fruit nutrition, there are very little information about its application and use in Hungarian sour cherry orchards. Therefore, the aim of this study is to examine the effects of foliar applications of B on nutrient uptake of tart cherry and fruit quality.

Materials and methods

The study was conducted from 2007 to 2009 in East Hungary on four major cultivars in Hungary: cv. 'Oblacsinszka', 'Érdi bőtermő', 'Újfehértói fürtös' and 'Petri'. All cultivars grafted on *Prunus mahaleb* rootstock. Trees spaced 7 × 5 m, and growing in an acidic sandy soil at

Újfehértó in East-Hungary (47°49'N, 21°40'E). Orchard was not irrigated in 2007 and 2008. For the purpose of the experiment, 20 trees were randomly selected from a population of trees with uniform characteristics with three replications. Regarding the earlier results (*Peryea,* 1994; *Peryea,* 2002; *Peryea* et al., 2003; *Wojcik* et al., 1999; *Wojcik,* 2006) foliar treatments were made in the spring at full bloom and five weeks after full bloom. The applied foliar applications are presented in *Table 1*.

Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan's Multiple Range Test, when ANOVA indicated significant ($P < 0.05$) variable effects.

Table 1: Applied foliar fertilization system (Újfehértó, Hungary, 2008–2009)

Applied nutrient	Dose (g/L)	Time of applications	Code of treatment
Control	–	–	C
B as $Na_2B_8O_{13}·4H_2O$	0.5	at full bloom 5 weeks after full bloom	

For spraying, Solubor (Disodium Octaborate Tetrahydrate – 20.9% B) was applied with 0.5% B solution concentration.

Soil sampling and preparation

Two soil samples were collected from two layers (0–30 and 30–60 cm) of all cultivars by using manual soil sampling equipment following the Hungarian and International sampling guidelines. Sampling was performed before investigation, at the beginning of the vegetation period in spring 2008. Sample preparation of the soil samples was performed according to Hungarian guideline (*MSZ 20135:1999*). Basic soil chemical and physical parameters were measured *(Table 2)* according to Hungarian guidelines.

Plant sampling and preparation

Plant (leaf) samples were taken at the standard sample time, right after the ripening. Healthy, well developed leaves were taken from all trees according to international conception and Hungarian sampling guidelines (Stiles and Reid 1966; *MI-08 0468-81*). Furthermore, inflorescences were sampled in the same trees at the stage of full bloom. Each plant sample was built with 100 leaves and 100 inflorescences, taking 5 leaves and 5 inflorescences from each of the 20 trees in a block. Replications were collected separately.

After drying, grinding and mixing, leaves and flowers were analysed. For leaf and flower 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).

Table 2: Chemical properties of the soil (Újfehértó, Hungary, 2008)

	Depth (cm)	
Parameters	0-30	30-60
pH (KCl)	4.67	3.90
pH (H2O)	6.63	5.24
$CaCO_3$ %	–	–
Salinity (%)	<0.02	<0.02
Plasticity index (K_A)*	25	25
Humus (%)	0.69	0.64
(NO_3^-+NO_2^-)–N (mg/kg)	1.6	1.1
NH_4^+–N (mg/kg)	1.2	6.1
P_2O_5 (mg/kg)	51	116
K_2O (mg/kg)	117	150
Mg (mg/kg)	69	50
Mn (mg/kg)	53	69
Cu (mg/kg)	2.1	8.7
Zn (mg/kg)	1.1	5.1
B (mg/kg)	0.12	0.14

*Plasticity index according to Arany is a soil parameter connection with clay content of soil, using in Hungary

Statistical Analyses

Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan's significant difference test at $P<0.05$.

Results and discussion

The soil of plantation was acidic sandy soil with low carbonate content. Humus content of soil was low but soil P and K were medium. Content of mineralized N form was low which pointed out that the mineralization processes are hindered under these conditions. Soil Mg and Mn content was low following from the soil properties. Soil Cu and Zn were low in the upper layer but their amount increased by the depth. Soil B was very low and predicted the low B supply of soil based on Wojcik (2003), proposed that hot water-soluble B concentration in the soil unsupplied with B was lower than 0.45 mg/kg, as a critical value for the most fruit crops grown under temperate climate.

Despite of low soil B content, the flower B status was sufficient at all cultivars. From our data it was evident that flower B content was significantly affected by spraying *(Table 3).* Our results are similar to those published by *Wojcik* et al. 2008 at 'Jonagold' apple trees. However, the degree of increment was depended on cultivars. The highest effect was observed at 'Oblacsinszka' while the lowest at 'Érdi bőtermő'. Beside the effect of cultivars, flower B content was affected by years also. Measured values were lower in 2009 than in 2008.

Leaf B content was sufficient according to the international and Hungarian standards *(Table 4).* Similarly to

Table 3: Results of flower analysis (Újfehértó, Hungary, 2008–2009)

Cultivars	Treatments	2008	2009
		Flower B (mg/kg dry matter)	Flower B (mg/kg dry matter)
'Újfehértói fürtös'	Control	34.90a	33.45a
	B-treatment	55.30d	42.14b
'Petri'	Control	45.33b	41.11b
	B-treatment	55.76d	49.34c
'Oblacsinszka'	Control	47.14b	48.03c
	B-treatment	66.64f	59.78e
'Érdi bőtermő'	Control	43.52b	42.32b
	B-treatment	47.14b	47.65c
Mean		49.47	45.48

In each column, means followed by the same letter are not significantly different (P<0.05).

Table 4: Results of leaf analysis (Újfehértó, Hungary, 2008–2009)

Cultivars	Treatments	2008	2009
		Leaf B (mg/kg dry matter)	Leaf B (mg/kg dry matter)
'Újfehértói fürtös'	Control	46.57a	39.64c
	B-treatment	49.66a	39.94c
'Petri'	Control	60.14d	44.08f
	B-treatment	58.6d	43.20f
'Oblacsinszka'	Control	49.66a	39.09b
	B-treatment	55.83b	35.21a
'Érdi bőtermő'	Control	56.44b	38.17b
	B-treatment	53.97b	41.42c
Mean		53,86	39,72

In each column, means followed by the same letter are not significantly different (P<0.05).

those obtained by Wojcik, 2006, B sprays had no consistent effect on summer leaf B status.

Spraying increased leaf B at two cultivars ('Oblacsinszka', 'Újfehértói fürtös') in 2008 and at 'Újfehértói fürtös', 'Érdi bőtermő' in 2009. Moreover, similarly that found flower analysis, leaf B content influenced strongly by cultivars and especially years (Table 4). In our experiment stronger year effect was observed at leaf B status than flower B status.

Moreover, leaf B content was lesser affected by spraying than flower B. It correlation with those published Hanson (1991b), who using foliar application of ^{10}B, and reported a rapid export of isotope from the spur leaves of sour cherry (*Prunus cerasus*) 3 to 9 days after treatment, the largest concentration of isotope is subsequently found in buds subtending the treated leaves.

In apple, a study by Hanson (1991a) demonstrated that the levels of foliar applied B decreased to levels similar to non-treated leaves within nine days of application.

Results pointed out that the absorption rate of foliar-applied B or translocation and mobilization of B in plant was limited as *Wojcik* et al., 2008 stated as well. Our results suggested that significant amount of sprayed B was not effective because a large amount of spray solution was lost on orchard soil surface. Moreover, a large part of flower B was lost also due to the petal fall. From these it is evident that the effectiveness of early spring boron applications are limited as stated by *Bramlage and Thompson,* 1962; *Khalil and Thompson,* 1965 and mostly affected the flower B status only. Our findings are in relation to those published by *Dell and Huang,* 1997; *Brown* et al., 2002 that an increase in fruit set as a result of foliar B sprays can be attributed to improve flower B status.

Furthermore, obtained results confirmed that earlier statements that timing of B maintenance sprays is not critical for 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), and B spraying has not consequent effect on leaf and fruit B content (*Peryea,* 2002, *Wojcik* et al., 2008).

Fruit analysis was fulfilled in 2008. It was found that the effects of B treatment were not consequent at all cultivars *(Table 5 and 6).*

B treatment significantly increased malic acid content of fruit at 'Oblacsinszka' and 'Érdi bőtermő' but decreased at 'Újfehértói fürtös'. Similarly, B treatment increased citric acid content at 'Petri' and 'Oblacsinszka' but decreased at 'Érdi bőtermő'. Vitamin C content was not affected significantly by treatment at most cultivars, except 'Petri' *(Table 5).*

Glucose and fructose content of sour cherry was significantly positively affected by B treatment at 'Oblacsinszka' and 'Érdi bőtermő'.

Moreover, sometimes, treatments had inconsistent effect on studied sugars of fruits.

Our results for the monosaccharides investigated are similar to those reviewed by *Wrolstad and Schallenberger* (1981) who reported mean values for a large variety of cherries as glucose and fructose. Sucrose was detected in

Table 5: Results of fruit analysis I. (organic acids) (Újfehértó, Hungary, 2008)

Cultivars	Treatments	Malic acid	Citric acid	Vitamin C
		mg/100g fresh weight		
'Újfehértói fürtös'	Control	1733.4c	73.4d	17.4f
	B-treatment	1706.6b	71.3c	16.8e
'Petri'	Control	1711.1b	63.4a	15.1c
	B-treatment	1716.6b	70.3c	13.2a
'Oblacsinszka'	Control	1724.4c	72.4c	11.9a
	B-treatment	1762.5g	76.5	12.4a
'Érdi bőtermő'	Control	1687.4a	70.6c	14.7c
	B-treatment	1733.9c	67.3b	13.8b
Mean		1721.99	70.65	14.41

In each column, means followed by the same letter are not significantly different (P<0.05).

Table 6: Results of fruit analysis II. (sugars) (Újfehértó, Hungary, 2008)

Cultivars	Treatments	Glucose	Fructose	Sucrose
		g/100g fresh weight		
'Újfehértói fürtös'	Control	5.44d	4.79c	0.53bc
	B-treatment	5.38a	4.80c	0.53bc
'Petri'	Control	5.38a	4.72a	0.51a
	B-treatment	5.40ab	4.74a	0.52ab
'Oblacsinszka'	Control	5.41b	4.73a	0.52ab
	B-treatment	5.45d	4.81cd	0.53b
'Érdi bőtermő'	Control	5.38a	4.73a	0.54cd
	B-treatment	5.42bc	4.82d	0.51a
Mean		5.41	4.78	0.52

In each column, means followed by the same letter are not significantly different ($P<0.05$).

small amounts in sour cherry cultivars, which is consistent with the findings of *Wrolstad and Schallenberger* (1981) who reported the absence of sucrose in some cultivars (e.g. cherries) and only low concentrations in others.

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

In conclusion, our results for the monosaccharides are similar to those obtained for organic acids: these inner parameters stronger affected by cultivars and ripening stage than applied treatments. However, it is concluded that under conditions of our experiment, B fertilization can be recommended in sour cherry culture to improve fruit quality and their appearance.

Moreover, it seems from obtained result that further investigations will be necessary to study the effects of boron foliar application on plant uptake and fruit quality.

Acknowledgements

This work was financed by NFÜ TECH_08-A3/2 2008-0373 grant.

Literature Cited

Boynton, D. (1966): Apple nutrition. In: Childers N. F. (eds.): Fruit nutrition. Horticultural Publications, Rutgers University in New Brunswick, N.J . (2nd ed.)

Bramlage, W.J. & Thompson, A.H. (1962): The effects of early-season sprays of boron on fruit set, color, finish, and storage life of apples. Proc. Am. Soc. Hortic. Sci., 80: 64–72.

Brown, P.H., Bellaloui, N., Wimmer, M.A., Bassil, E.S., Ruiz, J., Hu, H., Pfeffer, H., Dannel, F. & Römheld, V. (2002): Boron in plant biology. Plant Biol., 4: 205–223.

Dell, B. & Huang, L. (1997): Physiological response of plants to low boron. Plant Soil, 193: 103–120.

Gupta, U.C. (1979): Boron nutrition of crops. Adv. Agron., 31: 273–307.

Goldberg, S. (1997): Reactions of boron with soils. Plant Soil, 193: 35–48.

Fallahi, E., Fallahi, B., Neilsen, G.H., Neilsen, D. & Peryea, F.J. (2010): Effects of mineral nutrition on fruit quality and nutritional disorders in apples. Acta Hort., 868: 49–60.

Faust, M. (1989): Physiology of temperate zone fruit trees. Wiley, New York.

Hanson, E J. (1991): Movement of boron out of tree fruit leaves. HortScience, 26: 271–273.

Hanson, E J. (1991b): Sour cherry trees respond to foliar boron applications. HortScience, 26: 1142–1145.

Huang, L.,Ye, Z.,Bell, R.W. & Dell, B. (2005): Boron Nutrition and Chilling Tolerance of Warm Climate Crop Species. Annals of Botany, 96: 755–767.

Kamali, A.R. & Childers, N.F. (1970): Growth and fruiting of peach in sand culture as affected by boron and fritted form of trace elements. J. Amer. Soc. Hort. Sci., 95: 652–656.

Khalil, T.S. & Thompson, A.H. (1965): Seasonal content of boron of Stayman apple trees as influenced by boron sprays. Proc. Am. Soc. Hortic. Sci., 77: 35–42.

Mengel, K., Kirkby, E.A., Kosegarten, H. & Appel, T. (2001): Principles of plant nutrition, 5th ed. Kluwer Academic Publisher, Dordrecht

MI-08 0468-81. Plant analyses. Orchards. Sampling, preparation of samples, storing of samples. Hungarian Standards Institution. Ministry of Agriculture, Budapest (in Hungarian)

MSZ 20135: (1999): Determination of the soluble nutrient element content of the soil. Hungarian Standards Institution, Budapest (in Hungarian)

Peryea, F.J. (1994): Boron nutrition in deciduous tree fruit, p. 95–99. In: A.B. Peterson and R.G. Stevens (eds.) Tree fruit nutrition. Good Fruit Grower, Yakima, Wash

Perya, F.J. (2002): Properties and performance of boron spray products for apple. Acta Hort., 594: 211–215.

Peryea, F.J., Nielsen, D. & Neilsen, G. (2003): Boron maintenance sprays for apple: Early-season applications and tank-mixing with calcium chloride. HortScience, 38: 542–546.

Shorrocks, VM. (1997): The occurrence and correction of boron deficiency. Plant and Soil, 193: 121–148.

Stiles W.C. & Reid W.S. (1966): Orchard nutrition management. Cornell Cooperative Extension. Information Bulletin, 219.

Van Handel, E., Haeger, J. S. & Hansen, C. W. 1972. The sugars of some Florida nectars. Amer. J. Bot., 59 (10): 1030–1032.

Wann, F. B. (1966): Cherry nutrition. In: Childers N. F. (eds.): Fruit nutrition. Horticultural Publications, Rutgers University in New Brunswick, N.J . (2nd ed.)

Wojcik, P., Cieslinski, G. & Mika, A. (1999): Apple yield and fruit quality as influenced by boron applications. J. Plant Nutrition., 22 (9): 1365–1377.

Wojcik, P. (2006): 'Schattenmorelle' tart cherry response to boron fertilization. J. of Plant Nutrition, 29: 1709–1718.

Wojcik, P., Wojcik, M. & Klamkowski, K. (2008): Response of apple trees to boron fertilization under conditions of low soil boron availability. Scientia Horticulturae, 116: 58–64.

Wrolstad, R. & Schallenberger, E. (1981): Free sugars and sorbitol in fruits–acompilation from the literature. Journal of the Association of Official Analytical Chemists, 64: 91–103.