EFECTUL FERTILIZĂRII FOLIARE CU BOR ASUPRA REZISTENȚEI LA ÎNGHEȚ A MUGURILOR FLORIFERI, LEGĂRII FRUCTELOR ȘI CALITĂȚII POLENULUI LA UNELE SOIURI DE VIŞIN ÎN LETONIA

THE EFFECT OF FOLIAR BORON APPLICATION ON FLOWER BUD WINTERHARDINESS, FRUIT SET AND POLLEN QUALITY OF SOUR CHERRIES IN LATVIA

Feldmane Daina[1], Militaru Madalina[2], Butac Madalina[2], Pole Valentīna[1]
[1]Institute of Horticulture, Latvia University of Agriculture, e-mail daina.feldmane@llu.lv
[2]Research Institute for Fruit Growing Pitesti, Romania

Abstract

Boron (B) is essential nutrient element in plants, needed in the growth of new tissues and reproductive processes. B in the soil is poorly accessible if soil reaction is neutral. Postharvest sprays of B fertilizer increase the content of B in flower buds, but the effect on fruit set used to be inconsistent. The aim of the research was to determine the effect of foliar boron application on flower bud winterhardiness, fruit set and pollen quality of sour cherry cultivars 'Latvijas Zemais' and 'Zhukovskaya'. The research was carried out at the Institute of Horticulture, Latvia University of Agriculture, basing on sour cherry trial established in neutral soil. Foliar boron application was done once a year, at the BBCH stage 91. The percentage of damaged buds was calculated for the evaluation of winterhardiness. Fruit set was determined as the ratio of flowers and fruits. Leaf boron content was determined before the foliar boron application. Pollen quality was characterized by testing of pollen viability and germination capacity. Significant and cultivar depended impact of foliar B application on flower bud winterhardiness was detected in one of four years. Leaf B content varied from 21 to 24 mg kg $^{-1}$ in 'Zhukovskaya' and fruit set after foliar B application increased in whole range. B content in the leaf of 'Latvijas Zemais' ranged from 21 to 33 mg kg $^{-1}$, the increase of fruit set after one foliar B application was observed in the trees with boron content 23 to 26 mg kg $^{-1}$. The fluctuations of fruit set were less and pollen quality was higher if the trees were treated with B in both cultivars. At least one postharvest foliar B application can be recommended for sour cherries grown in neutral soils in Latvia with the taking into account initial B content in the leaf.

Cuvinte cheie: *Prunus cerasus***,** nutriție, fertilizare foliară, tratament postrecoltă, viabilitatea polenului, capacitate de germinare
Key words: *Prunus cerasus*, plant nutrition, leaf fertilizing, postharvest spray, pollen viability, germination capacity

1. Introduction

Boron (B) is essential nutrient element in plants, needed in the growth of new tissues by taking a part in cell wall formation and stabilization (Lehto et al., 2010) and involved in many physiological processes, including the response to the drought (Möttönen et al., 2001) and cold (Räisänen et al., 2006). B deficiency during crucial reproductive stages can lead to essential decrease of the yield. Thus appropriate supply of boron is necessary to obtain high yields, but B uptake from the soil is hindered in the conditions of drought (Huang et al., 1997) and decreased soil acidity from a pH value of 5 to 7 (Wear and Patterson, 1962).

Studies have shown that B is mobile in the plants of *Prunus* genus (Brown and Shelp, 1997). B has been withdrawn from autumn leaves and moved to flower buds in next spring, so postharvest and fall sprays of boron fertilizer caused increased content of boron in flower buds and flowers in sour and sweet cherries (Hanson, 1991a; Hanson, 1991b, Usenik and Štampar, 2007; Wójcik and Morgaś, 2013, Wójcik and Wójcik, 2007). However, the increased content of boron in the flowers not always led to enhanced fruit set. The effect was inconsistent and depended on the peculiarities of the cultivars (Usenik and Štampar, 2007) and on the initial content of boron in leaf (Hanson[b], 1991).

The aim of the research was to determine the effect of foliar boron application on flower bud winterhardiness, fruit set and pollen quality of sour cherry cultivars 'Latvijas Zemais' and 'Zhukovskaya' grown in Latvia.

2. Materials and methods

The research was carried out in Dobele, at the Institute of Horticulture, Latvia University of Agriculture. Sour cherry cultivars 'Latvijas Zemais' and 'Zhukovskaya' budded on the seedlings of mahaleb cherry (*Prunus mahaleb* L.) were studied. The trial was planted in the spring of 2008 in randomized block design with three repetitions for the trees with foliar boron application and control without it.

Soil properties in the trial: neutral clayic Podzoluvisol soil (pH 7.0) with medium content of plant available phosphorus and potassium - 160 mg kg^{-1} $P_2O_5$and 174 mg kg^{-1} K_2O. The content of organic matter was 1.5%. The fertilizers were given yearly as 12 g m^{-2} of N (ammonium nitrate), P_2O_5 (superphosphate) and K_2O (potassium chloride) in the soil in tree strips. Weeds, pests and diseases were controlled accordingly to integrated plant protection management.

In 2012 – 2015, the solution of boron acid (1.7 g per L of water) was sprayed on the leaf of cherries in the middle of August - after fruit harvest and growth cessation of the shoots, which corresponds to BBCH stage 91: shoot growth completed; foliage still fully green.

In 2013 – 2016, flower bud winterhardiness and fruit set were determined on sample shoots growing in the height of 1.2 – 1.5 m. For testing of the winterhardiness, the branches with flower buds were collected after the last winter frosts. Buds after swelling in room temperature were cut, evaluated visually and classified as partially damaged, completely damaged or undamaged. The percentage of damaged buds was calculated. For testing of fruit set, flowers and fruits after free pollination were counted. Fruit set was calculated as the ratio in percent of fruit and flower number.

Meteodata – air temperature and the amount of precipitation, was collected in meteo station LUFFT located within the orchard.

For clearer disclosing of foliar boron application effect, leaf boron content was determined before the spraying of the solution of boron acid in 2014 – 2015. Sample leaves were collected from the middle of one year old shoots in different sides of canopy and dried immediately at the temperature of 22-24°C. Boron content was determined by colorimetry at the Institute of Biology, University of Latvia.

Pollen quality was characterized by testing of pollen viability and germination capacity in 2014 – 2015. Flower buttons in balloon stage BBCH 59 were collected in the trial, the anthers were removed and dried at the temperature of 22-24°C. After 24 hours, the anthers have cracked and the pollen was released. Pollen viability was determined by the method of staining with acetic carmine. Fertile pollen coloured in carmine red, but sterile pollen remained less coloured or coloured in pink. Germination capacity was tested in vitro, by cultivating on solid nutrient medium which was made of 1.5 g agar, 15 g sucrose, 0.01 g boric acid (H_3BO_3) in 100 ml distilled water. The incubation lasted 16 hours at the temperature of 24°C and relative humidity of 70-90%. At least 100 pollen grains were observed and counted in 5 repetitions, and the germination rate was calculated. The pollen was considered germinated if the length of the pollen tube exceeded its diameter. The examination was made using the optical microscope Leica, with an objective × 40 for pollen viability; objective × 10 – for germination capacity. Of over 40% for germination capacity was considered as satisfying for a normal fructification.

Data were statistically processed using the analysis of variance and descriptive of statistics in SPSS software.

3. Results and discussion

3.1. Winterhardiness of flower buds

Significant differences of flower bud winterhardiness was observed between the cultivars and years. In general, 'Zhukovskaya' had smaller amount of damaged buds than 'Latvijas Zemais' (6.6% vs.17.7%). In the springs of 2013, 2015 and 2016, slight or no damages of flower buds were observed without essential impact of foliar boron application or year (Fig.1).

In 2014, flower buds of both cultivars were damaged to a greater extent. The minimal air temperature in the winter of 2014 (-19.5 °C in 3rd decade of January) did not differ essentially from the winters in other years (from -16.6 °C to -23.6 °C, onset in 3rd decade of December to 2nd decade of January). In 2014, the average temperature dropped under 0 °C later than in other years – it might be one of decisive factors affecting bud winterhardiness. The period with the average temperature below 0°C started in 2nd decade of January in 2014, but in from 1st decade of December until 1st decade of January – in other years.

In 2014, significant but contradictive effect of foliar boron application was detected. Positive effect of foliar B application was observed for 'Zhukovskaya', but opposite – for 'Latvijas Zemais'.

The trees of 'Latvijas Zemais' fertilized with boron had significantly more completely damaged flower buds than control trees – 28.8 and 10.7%, respectively. The percentage of partially damaged flower buds was not influenced by boron application (33.3% with B, 37.0% in control).The amount of completely damaged flower buds was similar for 'Zhukovskaya' with and without boron application (0 and 5%, respectively). But foliar B application resulted in essentially decreased amount of partially damaged flower buds – 16.4 % vs. 35.0% in the control.

Diverse role of B fertilizing on cold hardiness was detected in the study about Norway spruce (Räisänen et al., 2006). After freezing at low temperatures and short thawing time (until 8h) the results for freezing point of bud primordial shoots indicated slightly higher cold hardiness of the trees fertilized with B vs. control. However, in longer thawing time (more than 9 h) or in the freezing at low rates, trees fertilized with B showed slightly lower cold hardiness.

The influence of changing temperature and different response of the cultivars might be the reason of contradictive results of B effect on flower bud winterhardiness in our study.

3.2. Fruit set

3.2.1. Fruit set influenced by boron application and the year

The effect of foliar B application on fruit set differed significantly between the cultivars and years.As a whole, foliar B application did not increase fruit set of 'Latvijas Zemais'. The average fruit set was 27.2% in control, 19.5% - with B application. Significantly higher fruit set without B application was observed in 2013 and 2014, and the same tendency in 2016 (Fig.2). However, in 2015, fruit set tended to be higher in trees, which had foliar B leaf application.

Stabilizing effect of foliar B application on fruit set was detected – the fluctuations of fruit set were less in the trees treated with B within the years and among the individual trees in each year. Total range between the minimum and maximum of fruit set was 33.3 % in the trees with foliar B application, but 56.4 %– without it.

Generally, the average fruit set of 'Zhukovskaya' was lower than of 'Latvijas Zemais' (6.3 and 23.4% respectively, $p<0.05$). Fruit set of 'Zhukovskaya' was essentially influenced by growing season. In 2013, fruit set was atypically low both for the trees with and without foliar B leaf application (Fig.3). It might be explained by humid weather conditions during flowering and prolonged juvenile phase of trees of this cultivar. During 2014 – 2016, positive influence of foliar B leaf application was observed ($p<0.05$) – the average fruit set in trees with B application was 9.4 %, in the control - 6.8%. Stabilizing effect of B was observed also for 'Zhukovskaya' within the years 2014 – 2016: total range between the minimum and maximum of fruit set in control trees was 20.1%, but in the trees with B application – 11.6%.

In the spring of 2015, the positive effect of foliar boron application (sprayed in 2014) on fruit set was more pronounced than in other years for both cultivars.During flowering time in 2015 and during flower bud differentiation in 2014, the air temperatures and the amount of precipitation did not distinguish from other years. Significant impact of temperature and its amplitude before flowering was shown in the study of cherry fertility in Hungary (Nyéki et al., 2014). Also in our study, distinguishing temperatures were found during the period before flowering and after flowering in 2015. During 30 days before flowering, minimal air temperature was higher (-0.1°C) and diurnal amplitude of temperature less (9.5°C) than in other years (minimal temperatures from -1.7 to -5.6°C, diurnal amplitudes from 10.8 to 12.0 °C). Air temperature after flowering, from the 2nd decade of May until the end of May, in 2015 was lower (on average, 11.0°C) than in other years (on average, 14.5 °C to 16.1°C). Possibly, the trees with additional supply of B could realize their flower bud development and fruit formation more successfully than control trees in previously described temperatures in 2105.

3.2.2. Fruit set influenced by boron application and initial leaf B content

B content in the leaf of 'Latvijas Zemais' ranged from 23 to 26 mg kg $^{-1}$ in control trees and from 21 to 33 mg kg $^{-1}$in the trees which after leaf analysis were sprayed with B solution.

Positive and stabilizing effect of foliar B leaf application on fruit set in next spring appeared if B content in the leaf before spraying was in the range from 23 to 26 mg kg $^{-1}$ (Fig.4)- here the average fruit set after B fertilization was higher (32.0%)and fluctuations of it less than in control.

B application for the tree with leaf B content 21 mg kg $^{-1}$ resulted in fruit set under the average level (12%). Most probably, the spraying with B solution once was not enough and more supply of B was needed at such level. The trees with the leaf B content 31 and 33 mg kg $^{-1}$ had the fruit set close to the average level (20%) after B application, but none of control trees showed so high leaf B content.

Boron content in the leaf of 'Zhukovskaya' before B application varied from 21 to 24 mg kg $^{-1}$ in control trees, and from 21 to 23 mg kg $^{-1}$ in the trees which later were sprayed with B solution. Positive effect of foliar B application was observed in whole range of leaf B content.

Our results about leaf boron content in sour cherries ‘Latvijas Zemais’ and ‘Zhukovskaya’ coincided with the findings of E.J. Hanson who detected most consistently increased fruit set in trees of sour cherry ‘Montmorency’ containing B level from 19 to 25 μ/g (Hanson, 1991b).

3.3. Pollen quality

Generally, positive influence of foliar B application was observed both for ‘Latvijas Zemais’ and ‘Zhukovskaya’. Significant effect was more pronounced for pollen viability and germination capacity of ‘Latvijas Zemais’, but slight improvement of pollen viability appeared also for ‘Zhukovskaya’ (Fig.5).

The average viability of pollen in control trees of ‘Latvijas Zemais’ and Zhukovskaya’ was 78.6% and 90.1%, but in the trees with foliar B application it reached 88.7% and 94.2% respectively. High yielding sour cherry cultivars ‘Schattenmorelle IR’ and ‘Vowi’ had similar level of pollen viability in the study conducted in Poland (Szpadzik et al., 2008) to ‘Latvijas Zemais’ in our study.

Pollen germination capacity for ‘Latvijas Zemais’ was 45.2% in control, with foliar B application it increased till 55.5% whereas ‘Zhukovskaya’ showed alike pollen germination capacity in the trees without and with foliar B application – 53.1 and 54.4% respectively. Similar pollen germination capacity (53%) was determined in sour cherry ‘Kütahya’ in Turkey (Bolat and Pirlak, 1999).

4. Conclusions

Winterhardiness of flower buds and the effect of foliar boron application on, it strongly depended on the year and on the cultivar.

Foliar boron application decreased the fluctuations of fruit set and increased pollen quality in both cultivars – ‘Latvijas Zemais’ and ‘Zhukovskaya’.

For ‘Latvijas Zemais’, fruit set after foliar B application (once a year) increased in the trees with initial leaf boron content 23 to 26 mg kg $^{-1}$ whereas whole range of initial leaf B content was 21 to 33 mmg kg $^{-1}$.

For ‘Zhukovskaya’, initial leaf B content varied from 21 to 24 mg kg $^{-1}$and fruit set increased after foliar B application in whole range.

At least one postharvest foliar B application can be recommended for sour cherries grown in neutral soils in Latvia with the taking into account the initial B content in the leaf.

References

1. Bolat I., Pirlak L., 1999. An investigation on pollen viability, germination and tube growth in some stone fruits. Tr. J. of Agriculture and Forestry 23, 383-388.
2. Hanson E.J., 1991a. Movement of boron out of tree leaves. HortScience 26(3), 271-273.
3. Hanson E.J., 1991b. Sour cherry trees respond to foliar boron applications. HortScience 26(9), 1142-1145.
4. Huang I., Wang K., Bell R., 1997. Water supply influences boron uptake by transplanted oilseed rape (Brassica napus cv. Eureka) grown in low boron soil. In: Bell R.W., Rerkasem B. (eds) Boron in Soils and Plants. Developments in Plant and Soil Sciences, vol. 76. Springer, Dordrecht, pp.157-160.
5. Lehto T., Ruuhola T., Dell B., 2010. Boron in forest trees and forest ecosystems. Forest Ecology and Management 260, 2053-2069.
6. Möttönen M., Aphalo P.J., Lehto T., 2001. Role of boron in drought resistance in Norway spruce (Picea abies) seedlings. Tree Physiology 21, 673-681.
7. Nyéki J., Papp N., Lakatos L., Soltész M., Szabo Z., Hilsendegen P, Balmer M., Hegedus A., Halász J., Szabó T., 2014. Bloom phenology and fertility of sour cherry cultivars of Hungarian origin at two different growing sites. Acta Horticulturae 1020, 197-201.
8. Räisänen M., Repo T., Lehto T., 2006. Effect of thawing time, cooling rate and boron nutrition on freezing point of the primordial shoot in Norway spruce buds. Annals of Botany vol.97(4), 593-599.
9. Szpadzik E., Jadczuk-Tobjasz E., Łotocka B., 2008. Prelimeinary evaluation of pollen quality, fertility relations and fruit set of selected sour cherry cultivars in Polish conditions. Acta Agrobotanica vol. 61(1), 71-77.
10. Usenik V., Štampar F., 2002. Effect of foliar application of zinc plus boron on sweet cherry fruit set and yield. Acta Horticulturae 594, 245-249.
11. Usenik V., Štampar F., 2006. Effect of late season boron spray on boron accumulation and fruit set of ‘Summit’ and ‘Hedelfinger’ sweet cherry (Prunus avium L.). Acta agriculturae Slovenica 89, 51-58.
12. Wear J.I., Patterson R.M., 1962. Effect of soil pH and texture on the availability of water soluble boron in the soil. Soil Science Society of America Journal vol.26(4), 344-346.

13. Wójcik P., Morgaś H., 2013. Response of 'Burlat' sweet cherry trees to postharvest sprays of nitrogen, boron and zinc. Journal of Plant Nutrition vol. 36(3), 503-514.
14. Wójcik P., Morgaś H., 2015. Impact of postharvest sprays of nitrogen, boron and zinc on nutrition, reproductive response and fruit quality of 'Schattenmorelle' tart cherries. Journal of Plant Nutrition vol. 38(9), 1456-1468.
15. Wójcik P., Wójcik M., 2006. Effect of boron fertilization on sweet cherry tree yield and fruit quality. Journal of Plant Nutrition vol. 29(10), 1755-1766.

Figures

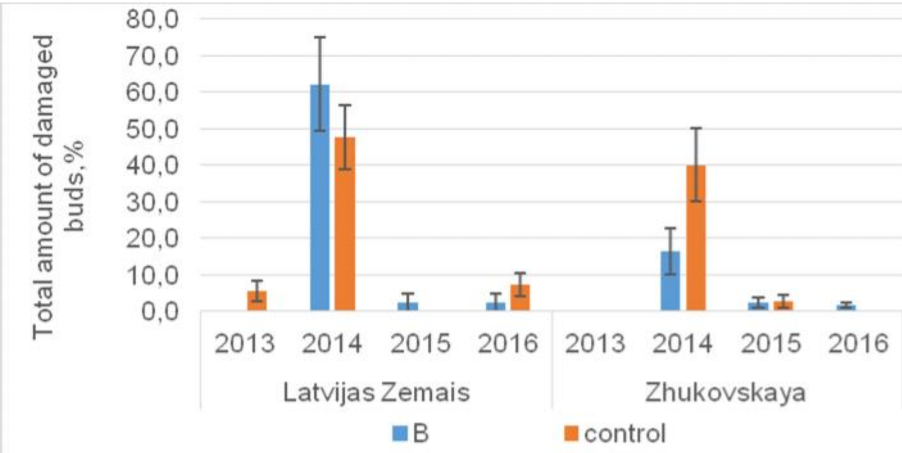

Fig. 1. Total amount of damaged buds of sour cherry cv. 'Latvijas Zemais' and 'Zhukovskaya' influenced by foliar boron application.

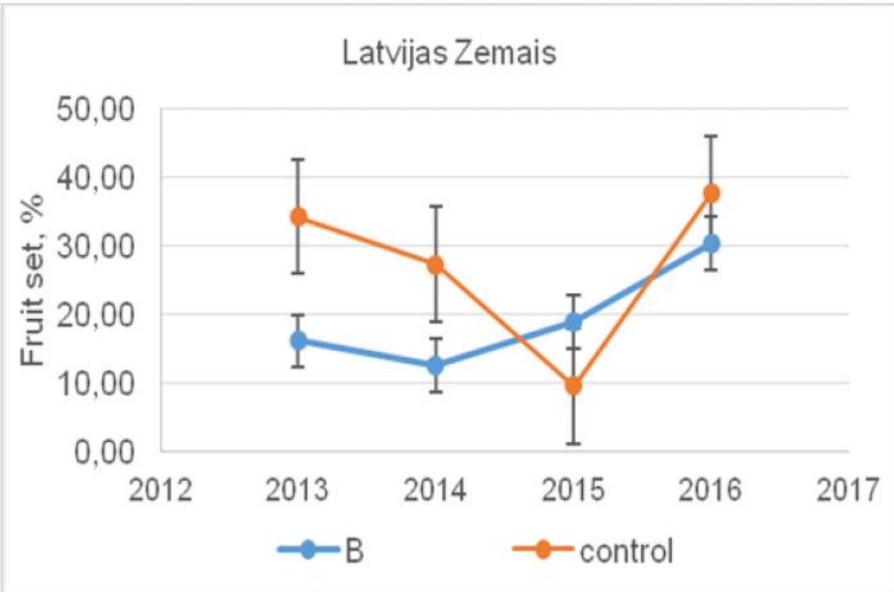

Fig. 2. The effect of foliar boron application on fruit set of sour cherry cv. 'Latvijas Zemais' in 2013 – 2016

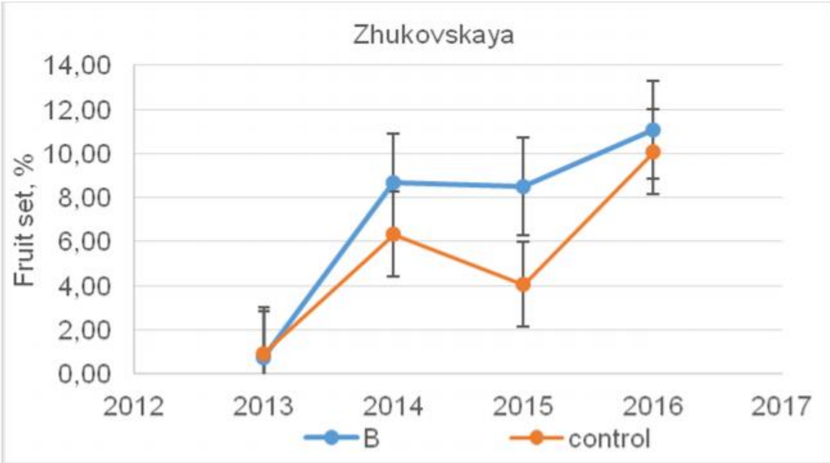

Fig. 3. The effect of foliar boron application on fruit set of sour cherry cv. 'Zhukovskaya' in 2013 – 2016

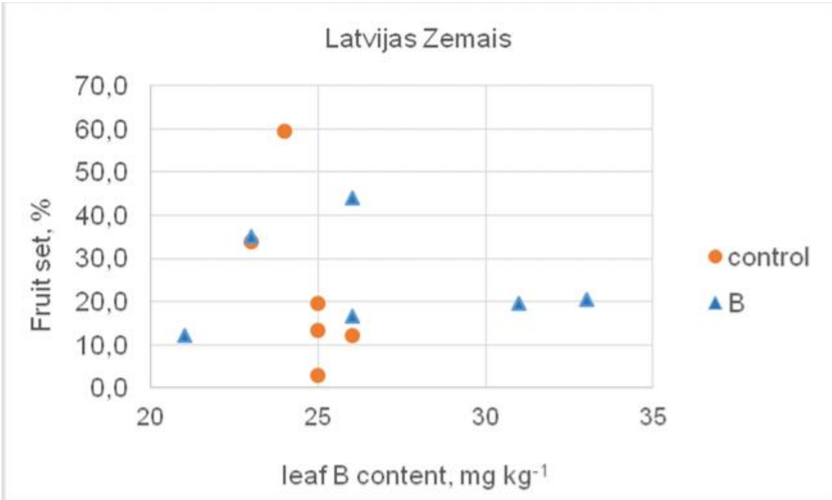

Fig. 4. The influence of foliar boron application on fruit set depending on leaf boron content before the spraying of boron solution for sour cherry 'Latvijas Zemais'

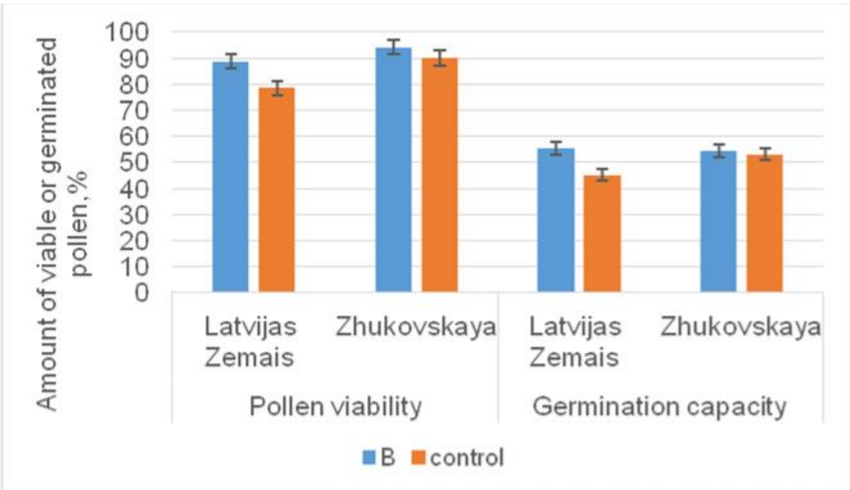

Fig. 5. The effect of foliar boron application on pollen viability and germination capacity of sour cherry cultivars 'Latvijas Zemais' and 'Zhukovskaya' in 2014 – 2015