DOI : 10.58993/ijh/2024.81.2.8

Indian J. Hortic. 81(2), June 2024: 167-173

Foliar nutrition induced changes in quality and storability of southern highbush blueberry cv. Sharpblue

N.D. Negi[*] and S.K. Upadhyay

Department of Horticulture and Agroforestry, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur 176062, Himachal Pradesh, India

ABSTRACT

In the present study, preharvest foliar sprays of boric acid, $ZnSO_4$ and $CaCl_2$, applied individually or in combinations tended to increase the growth, fruit set, yield and quality in southern highbush blueberry cv. Sharpblue. Boric acid sprayed either individually or in combination with other two nutrient elements showed the highest productivity (3.73 Mt/ha). However, $ZnSO_4$ increased the number of fruiting shoots and return bloom in the subsequent cropping year. Further, preharvest sprays of these nutrients increased the storage life of the fruits, while stored at 7°C. During storage, the rate of physiological weight loss and fruit decay was slower in fruits treated with $CaCl_2$ (0.25 and 0.5%) and combined application of these nutrients than control. The TSS content of fruits increased upto second week of storage and decreased thereafter. From this study it can be inferred that preharvest foliar sprays of boric acid, $ZnSO_4$ and $CaCl_2$ not only improve the yield and fruit quality in southern highbush blueberry cv. Sharpblue but also the storage life upto a month under refrigerated conditions.

Key words: *Vaccinium corymbosum*, PLW, berry shriveling, Sharpblue blueberry.

INTRODUCTION

Blueberries are being grown extensively in USA, Europe, New Zealand and Australia and at present, the USA is leading in its production (2,55,050 metric tonne) followed by Canada, Peru, France and Poland (FAO, 9). Traditionally, blueberries are grown in cooler northern hemisphere; however, with the development of new southern cultivars with low chilling requirements has made possible to the expansion of its production to the southern parts of the globe as well. Apart from some parts of Russian federation (FAO, 9), Japan (Takato, 18), China (Li and Chen 12) and Korean Republic are the major Asian countries where it is being grown (Anon., 1). In India, its commercial production has not been reported however, in Himachal Pradesh, southern highbush and rabbiteye cultivars have acclimatized well to prevailing conditions, and now bearing the commercial fruits (Negi and Upadhyay, 15). Owing to its numerous health benefits and increased awareness among the consumers, presently India is importing about 130 ton fresh blueberries annually, as it has huge potential in Indian markets, especially in metro cities (Anon., 2).

As blueberries have specific pH and nutrient requirements, hence it is very essential to provide balance nutrients for producing high quality fruits with better yields and due to shallow root system, fruit production can be altered even with a minor nutrient stress (Karlsons and Osvalde, 11). The studies on ideal soil and agroclimatic conditions, foliar feeding on the performance of blueberry is lacking. Other elements such as; B and Zn also plays the important role in fruit production. Boron at low concentrations increases fruit set and soluble solids in Brigitta blueberry, whereas in Legacy requirements of B for increasing fruit set and soluble solids is slightly higher (Cristian *et al*., 6). Karlsons and Osvalde (11) revealed that foliar sprays with micronutrients (Fe, Zn & B) increased fruit yields in highbush blueberries upto 134% as compared to untreated control, and recommended that the correct foliar fertilization could optimize the content of Fe, Zn and B in blueberry leaves.

Dariusz *et al.* (7) specified the role of nutrients in initial (B) and later (Mg, Fe, Mn & Zn) stages of crop development in blueberries. The application of nutrients to the plants through soil has disadvantage of being run-off, submergence, drought or leaching. Nutrients applied through foliar application can supply essential elements directly to the plants and developing fruits at times, when quick supply is desired. Moreover, foliar application of elements has more efficiency in its effectiveness and rapid plant response as compared to soil application when plants are deficient in particular elements. Therefore, boric acid, zinc sulfate and calcium chloride were applied to southern highbush blueberry cv. Sharpblue as foliar sprays either alone or in combination with the objective to study their effects on growth, flowering, fruiting and storage life of fruits under mid-hill conditions of Himachal Pradesh, India.

*Corresponding author: nanak_negi@yahoo.co.in

MATERIALS AND METHODS

This experiment was conducted in the experimental field of Department of Horticulture and Agroforestry, CSKHPKV, Palampur. The area represents mid hill zone of Himachal Pradesh, situated at 32° 5'55.05"N latitude, 76°32'32.94"E longitude and about 1240 m above mean sea level. This area experiences medium to heavy rainfall during monsoon (July-August) and moderate cold in winters. Soil of the experimental field is silty loam and slightly acidic having available N 219 kg/ha, P 59 kg/ha and K 249 kg/ha with high organic carbon. For this study, 24 plants of southern high bush blueberry cv. Sharpblue were selected on the basis of their uniform growth and size, planted at 1.5 m × 1.5 m spacing in raised beds. The basin area was kept slightly raised, mulched with pine needles and barks. In the month of December, well decomposed FYM (10-20 kg per plant) was applied, and in February, 150 g fertilizer mixture N:P: K (12:32:16) was mixed in the basins of each bush. The selected plants were given foliar sprays of boric acid (Merck) at 0.2 and 0.4%, $ZnSO_4$ (CDH, Mumbai) at 0.2 and 0.4%, $CaCl_2$ (EMPLURA) at 0.25 and 0.5%, and boric acid + $ZnSO_4$ + $CaCl_2$, at 0.2 + 0.2 + 0.25%, respectively twice in one growing season, first at petal fall stage and second at 15 days after first application. All the chemicals were of analytical grade (AR). Single plant was treated as one replication and replicated thrice. The experiment was laid on Randomized Block Design (RBD). Annual shoot growth was recorded at the end of growing season (December) by randomly selecting 5 shoots each from the plants with the help of scale and expressed in cm. For fruit set, before spraying of these micronutrients 10 fruiting shoots/ canes per plant were selected randomly and marked for calculating per cent fruit set. On these shoots, number of flower cluster and number of flowers per cluster was counted. The number of marked flower cluster and berries per cluster were also counted to work out the percent fruit set.

For determining return bloom, numbers of flowering shoot per plants were counted and percent increase over previous year was worked. Similarly, increase in the number of flower cluster per shoot was also counted and percent increase in number of flower cluster per shoot over previous year was determined. The production of berries per plant was estimated by using the following formula deVetter *et al*. (8). The productivity in terms of kg/ha was recorded for three years and data of last two years were pooled.

Ten fruits from each replication were weighed on a top-pan balance and there average value was expressed in grams (g). The total soluble solids content in fruits was determined with Erma Hand-held Refractometer (0-32°Brix). Titratable acidity of fruits was estimated by titrating fruit sample against 0.1 N NaOH and the amount of citric acid present in sample was calculated as per AOAC (3). The TSS : acid ratio was also worked out. For storage studies, fruits were packed in butter paper bags in two batches, comprising of 100 fruits each from all replications, and stored in refrigerator (Electrolux ER38FF) at temperature 7°C. (Fig. 1d). The periodical storage studies included weight loss and fruit decay (non destructive) and destructive studies included, variation in TSS and acid content of the fruits at 7, 14, 21, and 28 day intervals. The periodical loss of berry weight was measured by weighing 10 fruits each from the replicates at different intervals. The data on incidence of shriveling was also recorded at these intervals by counting the number of shriveled barries and per cent decaying was calculated. Total soluble solids and acidity in fruits were also determined at different storage intervals as per standard procedures.

Data on growth, flowering, fruiting and fruit quality at harvest was analyzed by using computer software ASSEX and results were compared by ANOVA table at 5% significance for randomized block design. For statistical analysis of data on storage studies of fruits on treatments, intervals and their interaction effects to compare the results by ANOVA table at same level of significance by using factorial randomized block experimental design.

RESULTS AND DISCUSSION

Preharvest foliar sprays of calcium chloride, boric acid and zinc sulphate given singly or in combination significantly influence the growth and flowering in southern highbush blueberry cv. Sharpblue. A perusal of data (Table 1), shows that the foliar spray of $ZnSO_4$ (0.2 & 0.4%) produced the longest shoot length in plants followed by combined application of these nutrients (boric acid + $ZnSO_4$ + $CaCl_2$ at 0.2 + 0.2% + 0.25%). This increment in shoot growth caused a significant increase in return bloom in terms of fruiting canes and number of flower cluster per shoot over previous year, as in blueberries flowering takes place on new shoots/ canes. Similarly, foliar spray of boric acid alone or in combination with $ZnSO_4$ and $CaCl_2$ significantly increased the number of fruits per cluster, and subsequently per cent fruit set as compared to plants sprayed with $CaCl_2$, $ZnSO_4$ and water (control). The highest fruit set (84.89%) was observed in plants sprayed with boric acid at 0.4%, closely followed by combined application of boric acid + $ZnSO_4$ + $CaCl_2$ at 0.2% + 0.2% + 0.25% and boric acid alone at 0.2 per cent. The overall fruit set was observed relatively low averaging from 75.48 to 84.89%, when

Table 1. Effect of foliar sprays of calcium, boron and zinc on growth and flowering in blueberry cv. Sharpblue

Treatment \ Parameter	Av. shoot growth (cm)	No. of fruiting cane/plant		% increase in No. of fruiting cane	Av. No. of flower cluster/cane		% increase in No. of flower cluster/cane	Av. No. of flowers/ cluster	Av. No. of fruits/ cluster	Fruit set (%)
		1st	2nd		1st	2nd		1st	2nd	
Boric acid 0.2%	50.34	14.78	18.73	26.73	7.09	9.08	28.07	7.37	6.22	80.39
Boric acid 0.4%	50.63	14.07	17.17	22.03	6.86	8.93	30.14	7.04	5.97	84.89
$ZnSO_4$ 0.2%	55.30	15.19	21.30	40.29	6.33	9.15	39.64	7.21	5.47	75.79
$ZnSO_4$ 0.4%	56.81	16.00	22.23	38.93	6.87	9.50	38.27	7.99	6.04	75.53
$CaCl_2$ 0.25%	49.01	15.79	17.50	10.82	6.56	8.82	28.28	7.96	5.55	75.48
$CaCl_2$ 0.5%	50.21	15.27	18.39	20.43	6.88	8.07	27.84	7.74	5.97	74.93
Boric acid + $ZnSO_4$ + $CaCl_2$ (0.2% + 0.2% + 0.25%)	54.64	15.82	19.67	24.34	6.69	9.25	38.26	7.15	5.78	80.87
Control (Water spray)	47.15	15.40	18.50	20.12	6.68	8.23	19.29	7.97	6.03	75.70
SE±	1.14	--	0.93	4.99	--	0.26	4.21	--	0.16	2.51
$CD_{0.05}$	3.25	NS	1.99	10.70	NS	0.55	9.53	NS	0.35	4.25

compared with other blueberry growing countries, as reported by Matthew and deVetter (14), where average fruit set has been reported to be as high as 98% in blueberry cv. Bluecrop in USA. The yield parameters *viz*., average number of fruits per plant, yield (kg/plant) and productivity (kg/ha) were also found to be significantly affected by the foliar sprays of boric acid, $ZnSO_4$ and $CaCl_2$ (Tables 2 & 3).

Boric acid applied alone or in combination with other two nutrients registered the highest fruits per plant, which further increased the estimated yield (1.05 kg/plant) and productivity (3.73 MT/ha). The estimated yield and productivity are dependent upon variables like; number of fruiting canes, fruit cluster per plant and average number of berry per cluster *etc*. Further, the data on productivity (kg/ha) was recorded for two more years after the foliar application of these nutrients and, it was observed that highest productivity of 6.29 MT per ha recorded in same treatment (Table 3), These findings are in line with the earlier reports of Cristian *et al.* (6) and Karlsons and Osvalde (11), where they observed increased fruit set in blueberries by the application of boron, Fe, Zn, Cu and Mn. They opined that yield increment by foliar sprays of these elements was due to increased fruit size. In similar lines, Blevins

Table 2. Effect of foliar sprays of calcium, boron and zinc on yield attributes and fruit quality of blueberry cv. Sharpblue.

Treatment \ Parameter	Av. No. of fruits/plant*	Yield (kg/plant)	Productivity (kg/ha)	Fruit wt. (g)	TSS (%)	TA	TSS : acid ratio
Boric acid 0.2%	601.7	1.02	3631.5	1.77	12.90	0.69	18.72
Boric acid 0.4%	620.3	1.05	3730.4	1.77	12.96	0.67	19.36
$ZnSO_4$ 0.2%	588.3	0.99	3358.1	1.74	11.01	0.70	15.72
$ZnSO_4$ 0.4%	579.4	0.98	3316.9	1.73	11.73	0.70	16.77
$CaCl_2$ 0.25%	532.5	0.96	3171.2	1.78	11.77	0.65	18.11
$CaCl_2$ 0.5%	543.6	0.97	3210.5	1.78	12.18	0.65	18.56
Boric acid + $ZnSO_4$ + $CaCl_2$ (0.2%+0.2%+0.25%)	609.5	1.04	3714.4	1.77	12.63	0.70	18.05
Control (Water spray)	514.0	0.94	3036.4	1.72	11.00	0.69	15.94
$CD_{0.05}$	85.25	0.05	236.2	0.03	0.72	0.03	1.20
SE±	42.36	0.02	105.7	0.01	0.33	0.01	0.55

*No. of fruiting cane × No. of fruit cluster per plant × average No. of berry per cluster

Table 3. Effect of foliar sprays of calcium, boron and zinc on yield attributes (kg/ha) of blueberry cv. Sharpblue

Treatment / Parameter	1st	2nd	Pooled
Boric acid 0.2%	4922.17	6177.77	5549.97
Boric acid 0.4%	5888.83	6693.33	6291.08
$ZnSO_4$ 0.2%	4672.18	5958.88	5315.53
$ZnSO_4$ 0.4%	4301.07	5956.66	5128.86
$CaCl_2$ 0.25%	3914.41	5539.99	4727.20
$CaCl_2$ 0.5%	4477.73	5543.33	5010.53
Boric acid + $ZnSO_4$ + $CaCl_2$ (0.2% + 0.2% + 0.25%)	5422.17	6447.77	5934.97
Control (Water spray)	4046.63	4817.77	4432.20
Mean	4705.65	5891.94	
$CD_{0.05}$			
T: 372.12	I : 196.65	T*I : NS	

(4) also reported foliar application of boron increased blueberry weight/plant by 10% over the four-year period resulting significant increase in fruit yield in cvs. Collins and Blueray.

Foliar application of these micronutrients also exerted a significant effect on fruit quality traits of southern highbush blueberry cv. Sharpblue. Calcium chloride sprayed twice at 0.25 and 0.5% showed the highest fruit weight (1.78 g) which was at par statistically with boric acid (0.2 & 0.4%) and combined application of boric acid + $CaCl_2$ + $ZnSO_4$ (Table 2), and the plants receiving only water sprays had minimum average fruit weight at harvest (1.72 g/fruit). These findings are in conformity to the earlier reports by Solhjooa *et al*. (17) in apple, in which they observed the increased fruit weight and other quality traits of Red Delicious apple by foliar spray of $CaCl_2$ and K. The increase in fruit size by the Ca might be attributed to the Ca^{2+} ion needed for cell division and expansion to control the growth (Marschner, 13). The fruit soluble solid content was also improved in plants treated with these nutrients than those receiving only water sprays (Table 2). It ranged between 11.00°B (control) to 12.96°B (boric acid at 0.4%) with corresponding TSS: acid ratio of 15.29 and 19.36, respectively. Similar results were also reported by Wojcik (19) on bluecrop blueberry by the foliar and soil applications of boron. The increase in TSS might be attributed to the improved transport of sugars in the phloem *via* the formation of sugar complexes. Similarly, titratable fruit acidity was also affected, and total acidity (TA) in the form of citric acid in fruits at harvest was significantly elevated by the application of boric acid, $ZnSO_4$ and their combined application as compared with $CaCl_2$ at both concentrations (0.25 and 0.5%). The increase in fruit TSS using foliar sprays of boron in different varieties of blueberry was reported earlier by Cristian *et al*. (6).

It is clear from the data (Table 4) that $CaCl_2$ treatments resulted in overall reduction in physiological weight loss of fruits during storage. The preharvest calcium sprays at both concentrations registered lowest fruit spoilage, and almost half of the fruits were healthy without showing any skin deformation and shrinking (56.66 - 56.11%). Whereas, in control, more than 60% fruits were having either shrinked or deformed shape. Although the observations on

Table 4. Effect of foliar sprays of boron, zinc and calcium on physiological fruits weight loss (%) and healthy fruits (%) in blueberry cv. Sharpblue during storage.

Treatments / Storage interval	Physiological fruit weight loss (%)					Healthy fruit (%)				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
Boric acid 0.2%	9.46	12.30	13.56	22.22	14.38	64.45	57.77	37.78	22.22	45.55
Boric acid 0.4%	8.85	12.23	13.69	20.34	13.78	64.45	53.33	42.22	24.45	46.11
$ZnSO_4$ 0.2%	7.80	12.06	14.81	22.93	14.40	66.67	53.32	44.45	22.22	46.66
$ZnSO_4$ 0.4%	7.83	11.21	13.76	24.16	13.49	64.45	57.78	44.45	24.45	47.78
$CaCl_2$ 0.25%	6.59	10.20	12.61	19.15	12.14	64.45	60.00	53.33	46.67	56.11
$CaCl_2$ 0.5%	6.15	9.45	10.67	16.66	10.73	66.67	60.00	53.32	46.67	56.66
Boric acid + $ZnSO_4$ + $CaCl_2$ (0.2%+0.2%+0.25%)	7.43	11.90	13.00	19.79	13.03	66.67	55.55	44.45	28.89	48.89
Control (Water spray)	8.25	13.88	14.54	25.57	15.55	60.00	48.88	33.33	15.55	39.44
Mean	7.80	11.65	13.33	21.35		64.72	55.83	44.17	28.89	
$CD_{0.05}$										
PWL:	T : 1.05		I : 0.99		T×I : 2.65	Healthy fruits:		T : 1.69	I : 1.90	T×I : 2.73

any fungal pathogen was not studied but none of the fruits were found infected visually by any fungal pathogen during 28 days of storage under refrigerated conditions (Fig. 1a to c). These findings are in line with the earlier reports by Pablo *et al*. (16) where they concluded that preharvest application of calcium decreased fruit deterioration in blueberries by increasing cell wall integrity through binding non-esterified pectins, and this impact was also seen in the next season as well. Chien and Shiow (5) opined that fruit decaying during storage might also occur due to improper temperature as they observed the main reason of decaying in cranberries due to chilling injury caused by low temperature (0°C) but at 5°C, no

Fig. 1. Effect of foliar sprays of boric acid, $ZnSO_4$ and $CaCl_2$ on fruits of southern highbush blueberry cv. Sharpblue in storage under refrigerator condition; a: CaCl2 at 0.5%; b: boric acid+$ZnSO_4$+$CaCl_2$ at 0.2+0.2+0.25%; c: control (water spray) & d: packaging of fruits for storage studies.

Table 5. Effect of foliar sprays of calcium, boron and zinc on TSS content and titratable acidity of blueberry fruits cv. Sharpblue during storage

Storage interval / Treatment	TSS (°Brix)					Titratable acidity (%)				
	D1	D2	D3	D4	Mean	D1	D2	D3	D4	Mean
Boric acid 0.2%	13.01	13.81	12.87	7.20	11.72	0.60	0.41	0.31	0.23	0.39
Boric acid 0.4%	13.57	14.43	13.20	7.40	12.15	0.59	0.40	0.34	0.25	0.39
$ZnSO_4$ 0.2%	13.10	14.40	13.77	7.82	11.27	0.62	0.37	0.31	0.23	0.38
$ZnSO_4$ 0.4%	13.03	13.78	13.50	8.10	12.10	0.61	0.42	0.29	0.24	0.39
$CaCl_2$ 0.25%	12.77	13.15	12.03	8.57	11.63	0.55	0.41	0.30	0.24	0.37
$CaCl_2$ 0.5%	12.04	12.90	11.50	8.60	11.35	0.52	0.41	0.32	0.26	0.37
Boric acid + $ZnSO_4$ + $CaCl_2$ (0.2%+0.2%+0.25%)	13.02	13.78	12.10	7.82	11.68	0.59	0.38	0.29	0.22	0.37
Control (Water spray)	14.13	14.70	13.50	6.40	12.18	0.55	0.39	0.24	0.19	0.34
Mean	13.08	13.86	12.80	7.74		0.58	0.39	0.30	0.26	
$CD_{0.05}$: TSS						TA				
T : 1.08	I : 0.76	T×I : 1.67				T : 0.01	I : 0.02		T×I : 0.02	

such decaying was occurred. From their studies, they concluded that 5°C temperatures was an optimum temperature for the storage of cranberries. Similarly, in our case also, the storage temperature was 7°C thus fruits were having shrinked skins without any injury or rotting symptoms after 28 days of storage (Fig. 1a to c). Similar findings were also reported by Hanson *et al*. (10), that pre-harvest foliar sprays of $CaCl_2$ (at 11 kg/ha) at five different intervals improved fruit firmness during storage and significantly reduced the crushed fruits in storage.

Preharvest foliar sprays of these nutrients also exerted a significant impact on changes in total soluble solid and TA of fruits during storage at 7°C (Table 5). The TSS content in fruits increased upto D_2 intervals reaching maximum to 13.86°B, thereafter it declined to 7.74°B at D_4 intervals. However, the fruit acidity was reduced with the advancement of storage duration (Table 5), but comparatively lesser reduction in fruit acid during storage was recorded in the fruits sprayed with boric acid, $CaCl_2$ and $ZnSO_4$. These findings are in conformity with the earlier reports of Yang *et al*. (20), in which they observed increase in TSS levels in blueberry cv. Draper during 1st and 3rd week of cold storage periods, but in 'Bluecrop' it was least variable among four cultivars.

From the present investigations, it is concluded that the foliar sprays of Zn and B and Ca increased vegetative growth, fruit set, yield and fruit quality in blueberry cv. Sharpblue under mid-hill zone of HP, India. The productivity of 3.73 Mt/ha in cv. Sharpblue blueberry was recorded with foliar sprays of boric acid, where blueberry production is in nascent stage. Further, these nutrients are also helpful for increasing storage life of fruits under refrigerated conditions for about one month.

AUTHORS' CONTRIBUTION

Conceptualization of research (ND Negi and SK Upadhyay); Designing of the experiments (ND Negi); Contribution of experimental materials (ND Negi and SK Upadhyay); Execution of field/lab experiments and data collection (ND Negi); Analysis of data and interpretation (ND Negi); Preparation of the manuscript (ND Negi).

DECLARATION

The authors declare that we do not have any conflict of interest.

REFERENCES

1. Anonymous 2020a. South Korean Blueberry Market. https://www.internationalblueberry.org/2014/03/28/south-korean-blueberry-market-snapshot/ #:~:text=The% 20 production%20 of %20 Korean%20 blueberries, and%20Chile%20 which%20sent%20650MT. Accessed June, 2020

2. Anonymous 2020b. The Economic Times. Blueberry for Urban Industry. https://economictimes.indiatimes.com/industry/cons-products/food/ig-international-imports-130-mt-of-blueberries-for-urban-consumers/articleshow/68093084.cms? from=mdr#:~:text=Fresh%20 fruit%20importing%20firm%20IG,and%20 Ahmedabad%2C%20among%20other%20cities. Accessed 2020.

3. A.O.A.C. 1980. *Official Methods of Analysis of Analysis,* (13th Edition) (Ed. W Horowitz (Ed.), Association of the official analytical chemists. Washington, DC. p. 1018.

4. Blevins, D.G., Scrivner, C.L., Reinbott, T.M. and Schon, M.K. 1996. Foliar boron increases berry number and yield of two highbush blueberry cultivars in Missouri. *J. Plant Nutr.* **19**: 99-113.

5. Chien, Y.W. and Shiow, Y.W. 2009. Effect of storage temperatures on fruit quality of various cranberry cultivars. Proc. IXth IS on *Vaccinium Eds.*: K.E. Hummer *et al. Acta Hortic.* **810**: 853-61.

6. Cristian Merino-Gergichevich, Eduardo Pacheco and Marjorie Reyes- Diaz. 2016. The effect of foliar boron spraying on the fruit features of Brigitta and Legacy highbush blueberry (*Vaccinium corymbosum*) cultivars. *Ciencia EInvestigacio. Agararia* **43**: 452-63.

7. Dariusz Wach and Marzena, Błazewicz-Wozniak. 2012. Effect of foliar fertilization on yielding and leaf mineral composition of highbush blueberry (*Vaccinium corymbosum* L.). *Acta Sci. Pol. Hortorum Cultus*, **11**: 205-14.

8. DeVetter, L.W., Watkinson, S., Sagili, R. and Lawrence, T. 2016. Honey bee activity in northern highbush blueberry differs across growing regions in Washington State. *HortSci.* **51**: 1228-32.

9. F.A.O. 2018. Data base http://www.fao.org/faostat/en/#data/QC/visualize. Data retrieved on June, 2021.

10. Hanson, E.J., Beggs, J.L. and Beaudry, R.M. 1993. $CaCl_2$ applications to increase highbush blueberry firmness. *Acta Hortic.* **346**: 354-59.

11. Karlsons, A. and Osvalde, A. 2019. Effect of foliar fertilization of microelements on highbush blueberry (*Vaccinium corumbosum* L.) nutrient status and yield components in cutover peatlands. *Agron. Res.* **17**: 133-43.

12. Li, Y., Sun, H. and Chen, L. 2017. The blueberry industry of China: the past 10 years and the future. *Acta Hortic*. **1180**: 531-36.

13. Marschner, P. 2012. *Mineral Nutrition of Higher Plants* (3rd ed.), 651 p, Academic Press, London, UK.

14. Matthew Arrington and Lisa Wasko DeVetter. 2017. Foliar applications of calcium and boron do not increase fruit set or yield in northern highbush blueberry (*Vaccinium corymbosum*). *Hortsci.* **52**: 1259-64.

15. Negi, N.D. and Upadhyay, S.K. 2017. Evaluation of different blueberry genotypes under mid-hill conditions of Himachal Pradesh. *Indian J. Hortic.* **74**: 156-61.

16. Pablo Angeletti, Hilda Castagnesso, Elisa Miceli, Laura Terminiello, Analia Concellon, Alicia Cheves, Alicia Chavesand Ariel, R. Vicente. 2010. Effects of preharvest calcium application on post harvest quality and cell wall degradation of two blueberry (*Vaccinium corymbosum*) varieties. *Post harvest Biol. Technol.* **58**: 98-103.

17. Solhjooa, S.A., Gharaghania, B. and Fallahic, E. 2017. Calcium and potassium foliar sprays affect fruit skin color, quality attributes, and mineral nutrient concentrations of ‘Red Delicious’ apples. *Int. J. Fruit Sci.* **17**: 358-73.

18. Takato Tamada. 2009. Current trends of blueberry culture in Japan. *Acta Hortic.* **810**: 109-16.

19. Wojcik, P. 2005. Response of ‘Bluecrop’ highbush blueberry to boron fertilization. *J. Plant Nutr.* **28**: 1897-906.

20. Yang, W.Q., Harpole, J.C., Finn, E. and Strik, B.C. 2009. Evaluating berry firmness and total soluble solids of newly released highbush blueberry cultivars. *Acta Hortic.* **810**: 863-67.

Received : February, 2024; Revised : May, 2024; Accepted : June, 2024