Optimizing biostimulant strategies for enhanced container-grown highbush blueberry cultivation in a changing climate

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INTRODUCTION

The use of biostimulants in modern agriculture is attracting more interest than ever, particularly under climate changes that are affecting the growing conditions of various horticultural crops

Plant growth promoting rhizobacteria (PGPR) are microorganisms that can colonize plant roots and considerably increase growth and yield under stressful condition

Silica (Si) is a mineral element that increase plant resistance to various abiotic and biotic stresses such as salinity, drought, flooding, freezing and mineral deficiency

+ **Higher yield and improved fruit quality**
+ **Enabling high plant density**
+ **Reduce nutrient leaching**

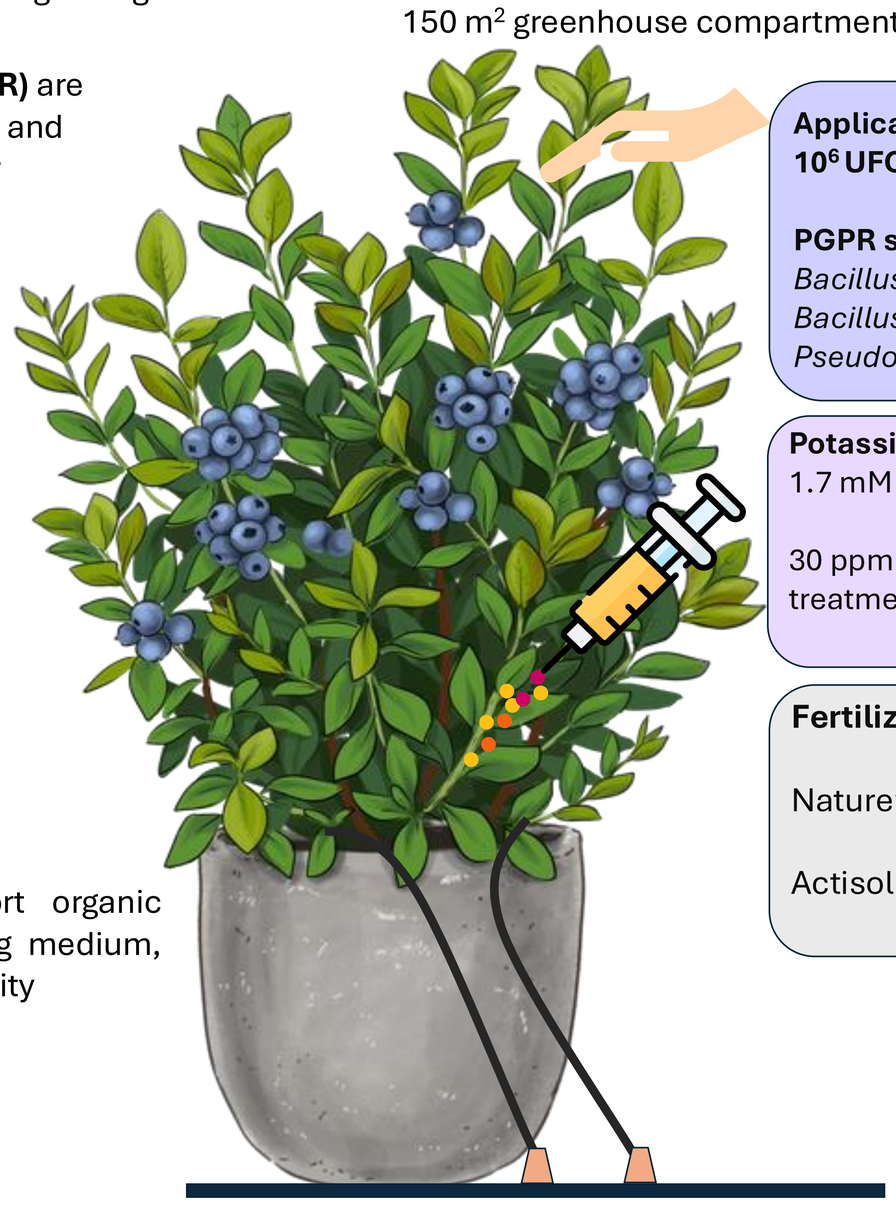
- Challenges related to ensuring sufficient nutrient absorption
- Stabilizing pH levels
- Salinity issues

OBJECTIVES

1. Observe how applications of PGPR could support organic fertilizers, improve their mineralization in the growing medium, and promote mineral absorption, growth, and productivity
2. Evaluate the interaction between the supply of silica and PGPR in the rhizosphere and the agronomic performance of the plant

MATERIALS AND METHODS

90 highbush blueberry plants from 10 cultivars (Aurora, Bluegold, Bluejay, Blueray, Clockwork, Duke, Earliblue, Last Call, Liberty, and Spartan) were deployed in a 150 m^2 greenhouse compartment at Laval University over one season (2023)



Application 1x/month from May to September of 10 mL x 10^6 UFC mL^{-1} per strains

PGPR strains used
Bacillus pumilus LBUM494
Bacillus velezensis LBUM279
Pseudomonas synxantha LBUM223

Potassium silicate (25% SiO_2, 15% K_20) at a rate of 1.7 mM via fertigation

30 ppm of potassium sulfate (K_2SO_4) was added to other treatments (CRTL and PGPR) via fertigation

Fertilizers	Total nitrogen/season
Nature's Source 10-4-3 (weekly)	13 g N/plant
Actisol 5-3-2 (1x/month)	4.4 g N/plant

RESULTS

Table 1. Marketable yield, non-marketable yield , fruit size, sugars content and anthocyanins and polyphenols contents of blueberries harvested from 10 container-grown highbush blueberry cultivars subjected to three biostimulant treatments: PGPR, PGPR+Si (Potassium silicate), CTRL (Control), in 2023.

		Marketable yield (g/plant)	Non-marketable yield (g/plant)	Fruit size (g)	Soluble sugars (° Brix)	Anthocyanins (mg/g DW)	Polyphenols (mg/g DW)
Cultivar	**Aurora**	398.2 cd	10.37 bc	2.11 ab	12.0 bcde	8.65 a	14.7
	Bluegold	1036.2 a	43.8 a	2.21 ab	9.0 e	7.75 ab	20.6
	Bluejay	333.3 cd	14.6 bc	1.92 b	13.1 a	6.94 bcd	12.8
	Blueray	632.1 bc	21.6 abc	2.61 a	12.1 bcd	7.10 abc	12.9
	Clockwork	516.0 bc	30.5 ab	1.90 b	11.8 bcde	5.10 e	12.9
	Duke	788.4 ab	22.4 abc	2.07 ab	10.7 de	7.03 abcd	11.5
	Earliblue	176.6 d	4.8 c	1.88 b	14.0 a	5.46 de	11.8
	Lastcall	474.0 bcd	17.5 bc	2.62 a	12.5 abc	7.87 ab	13.1
	Liberty	780.7 ab	23.8 abc	2.47 a	10.9 cde	5.75 cde	13.3
	Spartan	553.5 bc	31.5 ab	2.61 a	12.5 ab	4.92 e	10.6
Biostimulant	**PGPR**	535.7 a	22.8 a	2.08 a	12.1 a	6.72 a	13.9 a
	PGPR+Si	560.9 a	18.2 a	2.33 a	12.1 a	6.59 a	13.0 a
	CTRL	610.1 a	25.3 a	2.31 a	11.5 a	6.64 a	13.4 a
Sources of variation – Significance level							
Cultivar (C)		***	**	*	**	***	**
Biostimulant (B)		ns	ns	ns	ns	ns	ns
C × B		ns	ns	ns	ns	ns	***

Means followed by the same letter are not significantly different within a column and a factor at $p \leq 0.05$ (protected Fisher's LSD test) ; ns, not significant; *, **, ***, significant at $p \leq 0.05$, 0.01, 0.001, respectively

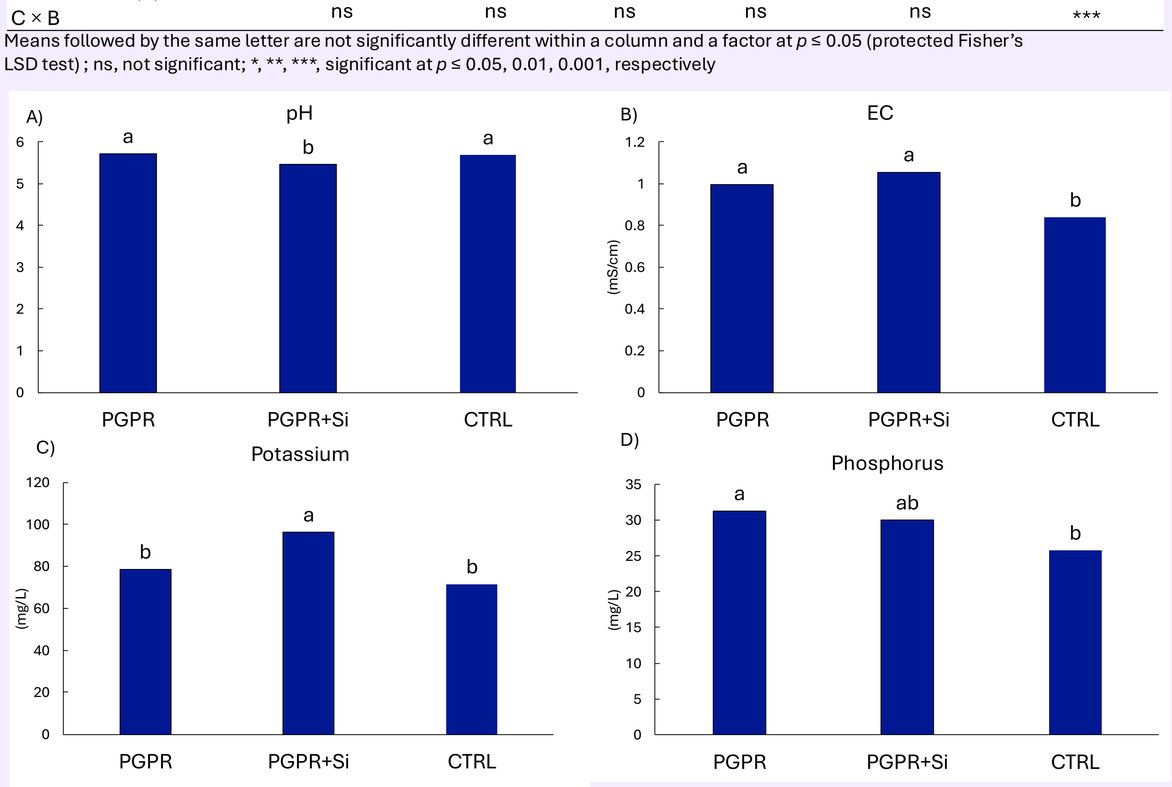


Figure 1. Mean comparisons for A) pH, B) electrical conductivity (EC), C) potassium concentration and D) phosphorus sampled in container-grown highbush blueberry plants subjected to three biostimulant treatments (PGPR, PGPR+Si (Potassium silicate), CTRL (Control) in 2023 (on average for the 10 cultivars and two sampling dates). Means followed by the same letter are not significantly different ($p \leq 0.05$) (n=180).

Fruit productivity

On average, **plants produced 569 g of marketable fruits for the 2023 season**. Our results showed that PGPR and Si had not impact on marketable and unmarketable yield, although differences were observed among the cultivars (P=0.002), with Bluegold, Duke and Liberty presenting higher yield than Aurora, Bluejay and Earliblue (Table 1)

Photosynthetic parameters

The biostimulant treatments did not affect the leaf chlorophyll relative content (SPAD unit) over a two-month period, but variations among cultivars were observed for June (P=0.038) and July (P=0.003). An interaction between cultivars and biostimulants (P<0.001) was observed in August, as SPAD units for Aurora with PGPR being higher than any other treatments and cultivars averaging 47.9 SPAD units (not shown)

Chemical and biological properties of growing media

Growing medium parameters were affected by the biostimulant treatments

- The **pH level** was lower with PGPR+Si (5.45) compared to PGPR (5.71) and CTRL (5.68) (Fig. 1A)
- **Electrical conductivity (EC)** of the growing medium was higher for PGPR+Si (1.05 mS/cm) compared with CTRL (0.83 mS/cm), but similar to PGPR (0.99 mS/cm) (Fig.1B)
- Even though every treatment contained egal concentration of potassium, PGPR+Si had a higher **potassium content** in the growing medium (Fig. 1C)
- **Phosphorus content** of the growing medium was higher for the PGPR treatment (31.29 mg/L) compared to the CTRL (25.78 mg/L), while the PGPR+Si treatment (29.99 mg/L) was higher, but not significantly different, than the CTRL

CONCLUSION

- PGPR did not improve yield or fruit quality in this study
- Differences were observed between cultivars
- PGPR can improve the properties of the growing medium and nutrient availability, which may enhance plant growth in container-grown organic blueberries over longer term
- The impact of biostimulants should be observed over an extended period and across multiple growing seasons to draw further conclusions

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