Rhize Vegetative and Bloom Fertilizers effects on Hydroponically Grown Vegetables

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INTRODUCTION

Controlled environment agriculture requires precision in the application of the appropriate agronomic input to optimize plant growth and agronomic productivity. Hydroponics is the soil-less cultivation of plants using mineral nutrient solutions (Sardare and Admane, 2013). Typically, sustainable fertilizer input and biofertilizer use in nutrient solutions are critical for hydroponic production (Phibunwatthanawong and Riddech, 2019). Plant growth and yield are remarkably affected by the type and rate of fertilizer application (Baiyin et al., 2021). There are many different types of fertilizers on the market with different elemental composition. These differences can affect plant growth and yield. Rhize products include a two-part mineral nutrient product line that is designed for vegetative and generative (bloom) plants. The vegetative fertilizer product (Vegetative A&B) is used for growing leafy vegetables such as lettuce, kale, Swiss chard. Previous research found the greatest nutrient accumulation in the plant shoots, with the highest lettuce yield obtained at a high nutrient solution concentration and flow rate (Dalastra et al., 2020).

OBJECTIVES

The present study evaluated the effect of Vegetative A&B on lettuce, kale and Swiss chard plant growth, leaf pigmentation, and yield of hydroponic vertical tower production.

METHODOLOGY

The study was carried out between December 2023 and January 2024 in the greenhouse facility at the Department of Plant, Food, and Environmental Sciences. Four-week-old rockwool-grown seedlings of lettuce, kale and Swiss chard were grown in hydroponic vertical tower (Figure 1) under 12-hr day/night light cycle under full-spectrum LED lighting conditions at an average temperature of 21°C.

Figure 1. Hydroponic vertical tower production of leafy greens using the Vegetative A&B nutrient solutions.

The experiment was run for six weeks to examine the effect of different nutrient solutions on the growth and productivity of the three leafy vegetables. The experimental treatment was the different type of nutrient solutions i.e., Vegetative A&B with [redacted] nutrients being the control (Control 1). A second control derived from pyroligneous acid (not yet commercialized) was included in the trial and labelled as Control 2. The nutrient solution applications were based on the manufacturer's instructions (below). The nutrient solutions were replaced weekly, and the EC was recorded for each solution.

Table 1. Rhize fertilizer products of Vegetative and Bloom A&B.

Nutrient solutions	Rate and EC at W1	Rate and EC at W2	Rate and EC at W3	Rate and EC at W4	Rate and EC at W5	Rate and EC at W6
Vegetative A&B	¼ strength of control (EC = 0.55)	1.75 mL of each VA and VB / L of water (EC = 0.84)	2 mL of each VA and VB / L of water (EC = 0.98)	2.25 mL of each VA and VB / L of water (EC = 1.14)	2.5 mL of each VA and VB / L of water (EC = 1.32)	2.75 mL of each VA and VB / L of water (EC = 1.43)
[redacted] (control)	¼ strength of control W1 (EC = 0.55)	¼ strength of control W2 (EC = 0.77)	¼ strength of control W3 (EC = 1.01)	1/2 strength of control W3 (EC = 1.19)	1/2 strength of control W4 (EC = 1.36)	1/2 strength of control W5 (EC = 1.49)

W1 – W6, week 1 to 6; Note that EC of control was adjusted to match that of VA+VB nutrient solution.

RESULTS

Visual observations of the plants showed that the overall growth and looks of the lettuce, Swiss chard and kale in the hydroponic vertical tower containing the Vegetative A&B were better than those for the control treatment as shown in Figure 2. These include the leaf size, number of leaves and plant height, but not the colour of the leaves. However, the second control (Control 2) made from pyroligneous acid had the least growth parameters compared to all the other treatments (photo not presented but we presented the quantitative data).

Figure 2. Photos of hydroponic tower produced lettuce (left), Swiss chard (right) and kale (right) plants using the Rhize Vegetative A&B (top photo) compared to a commercial nutrient solution as control (Control 1, bottom photo).

Leaf pigmentation slightly varied among the treatments (Figure 3). Vegetative A&B consistently produced plants with the highest chlorophyll content compared to the two controls. This was demonstrated by the comparatively high SPAD values of leaf greenness for all the three plant species grown in Vegetative A&B nutrient solution (Figures 3A-C).

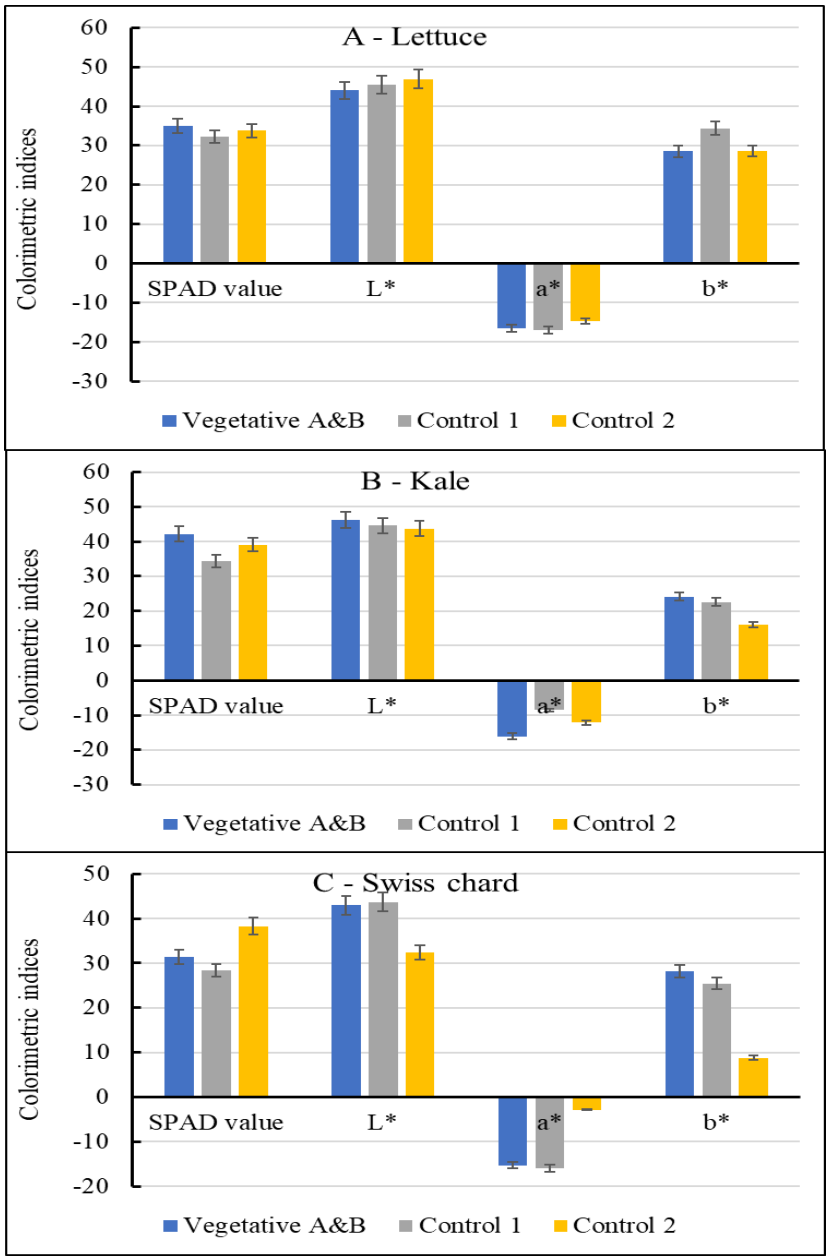

Figure 3. Colorimetric indices of the leaves of lettuce (A), kale (B) and Swiss chard (C) as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

Additionally, the colorimetric indices determined by CIELAB color space, also referred to as L*a*b*, where L* expressed lightness, a* expressed the red/green coloration, and b* expressed the yellow/blue coloration of the plant leaves (Figure 3). Both L* and a* were similar in the plants but b* (the yellow/blue) coloration was lower in lettuce but higher in kale and Swiss chard grown with Vegetative A&B nutrient

solution compared to Control 1 and Control 2. This could suggest the need for higher concentration of Vegetative A&B nutrient solution for lettuce production although they were not visibly chlorotic. It was found that the only plants that their number of leaves and plant heights (Figure 3B) were increased by Vegetative A&B was kale, but was similar with plants grown in the commercially available nutrient solution product (Control 1) for lettuce (Figure 3A) and Swiss chard (Figure 3C).

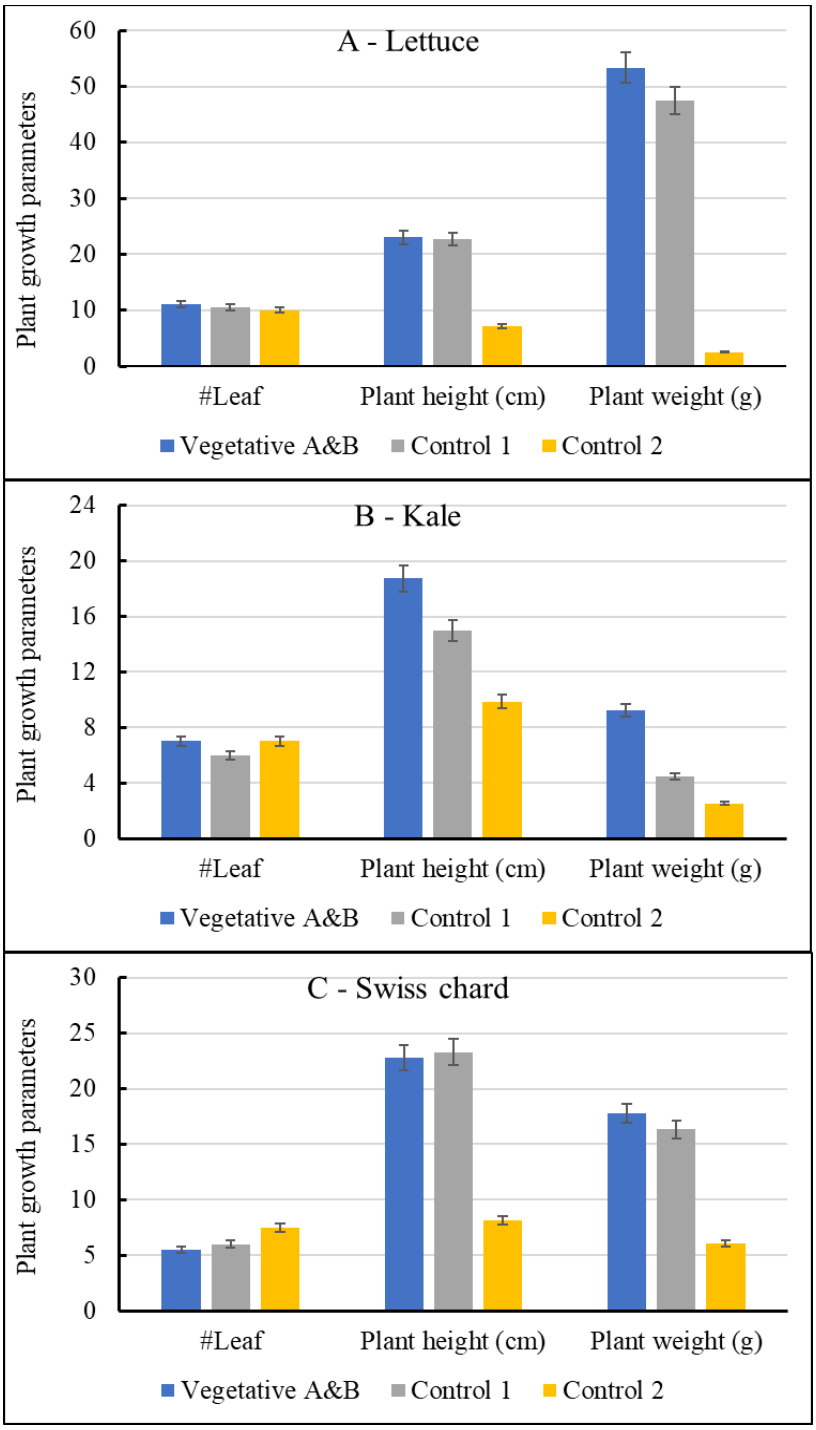

Figure 4. Plant growth and yield parameters of lettuce (A), kale (B) and Swiss chard (C) as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

Overall, the Control 2 had the least effect on plant growth (Figures 3A-C). It is worth noting that the yield as determined by harvested plant fresh weight was significantly highest for lettuce, kale and Swiss chard grown in the Vegetative A&B nutrient solution compared to both controls (Figure 3A-C).

Figure 5 showed elongated roots in all the plant species grown in the Control 2 compared to the Vegetative A&B nutrient solution, but it did not translate into yield in the former. For hydroponic systems, excessive root growth can potentially be demerit.

Vegetative A&B

Control 2

Figure 5. Root growth of lettuce (A), kale (B) and Swiss chard (C) as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

°Brix is a measure of dissolved solids in a liquid and is commonly used to measure plant tissue soluble sugar content. Comparatively, the Vegetative A&B nutrient solution increased the soluble sugar content of all the leafy greens, especially in the kale and Swiss chard leaf tissues (Figure 6A-C). It was low in Control 1 plants compared Control 2 plants.

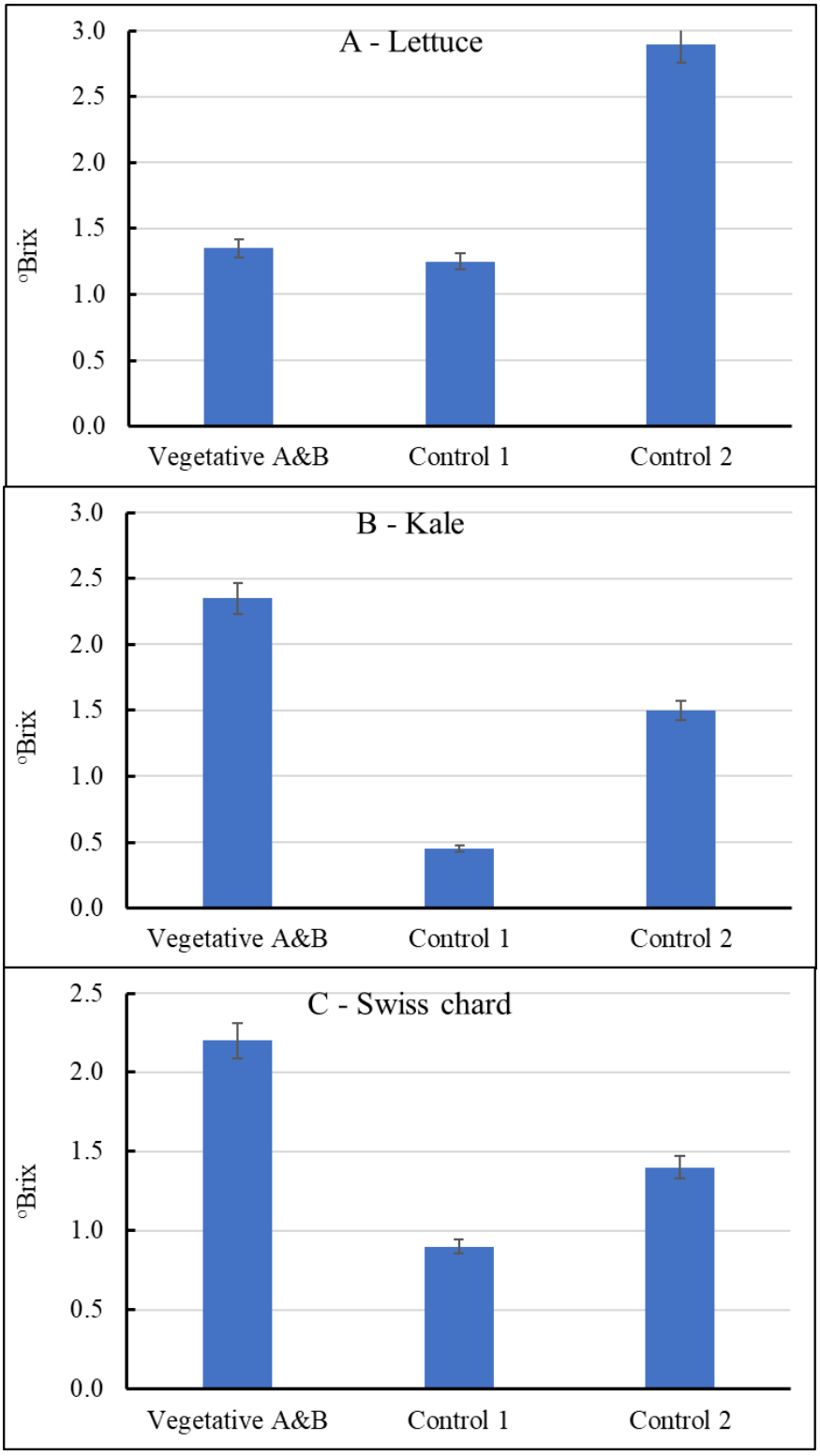

Figure 6. °Brix of lettuce (A), kale (B) and Swiss chard (C) as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

There were variations in the nutrient uptake and accumulation in the lettuce leaf tissues as represented in Figure 7A-D. Nitrate was high in Control 2 followed by Vegetative A&B, potassium was high in Control 1 followed by Vegetative A&B, calcium was high Control 2 followed by Vegetative A&B, and sodium was the least in plants grown in Vegetative A&B. Consumers will be motivated with the low sodium accumulation in lettuce grown in Vegetative A&B.

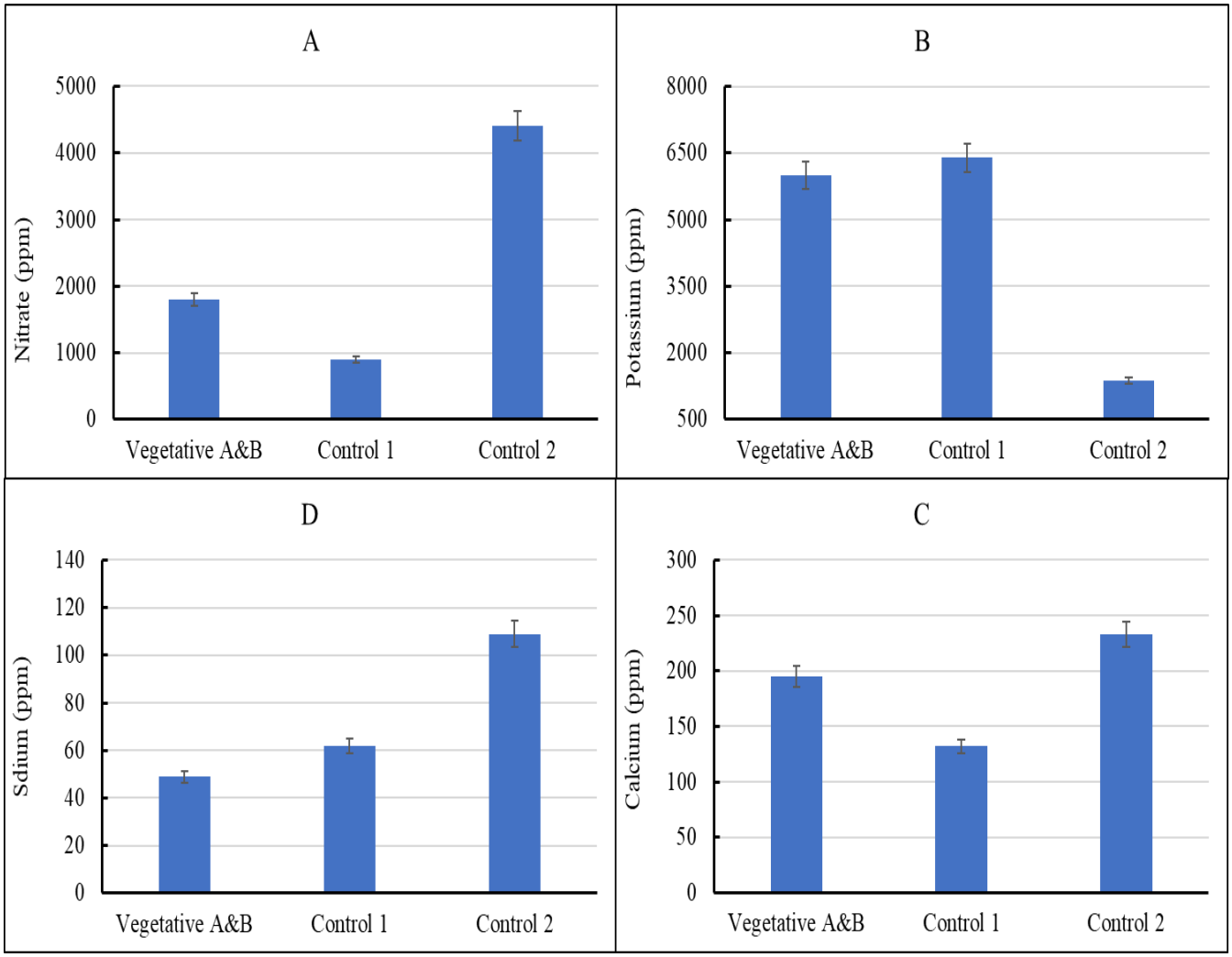

Figure 7. Nitrate, potassium, calcium and sodium content of lettuce as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

Figure 8 showed that nitrate, potassium, and calcium were highest in kale leaf tissues harvested from plants grown in the Vegetative A&B nutrient solution compared to the Controls 1 and 2 nutrient solutions. Kale grown in the commercially available nutrient solution, Control 2, led to increased sodium accumulation in the leaf tissues. These nutrients are important for plant metabolism and growth and development processes, which can potentially benefit consumers.

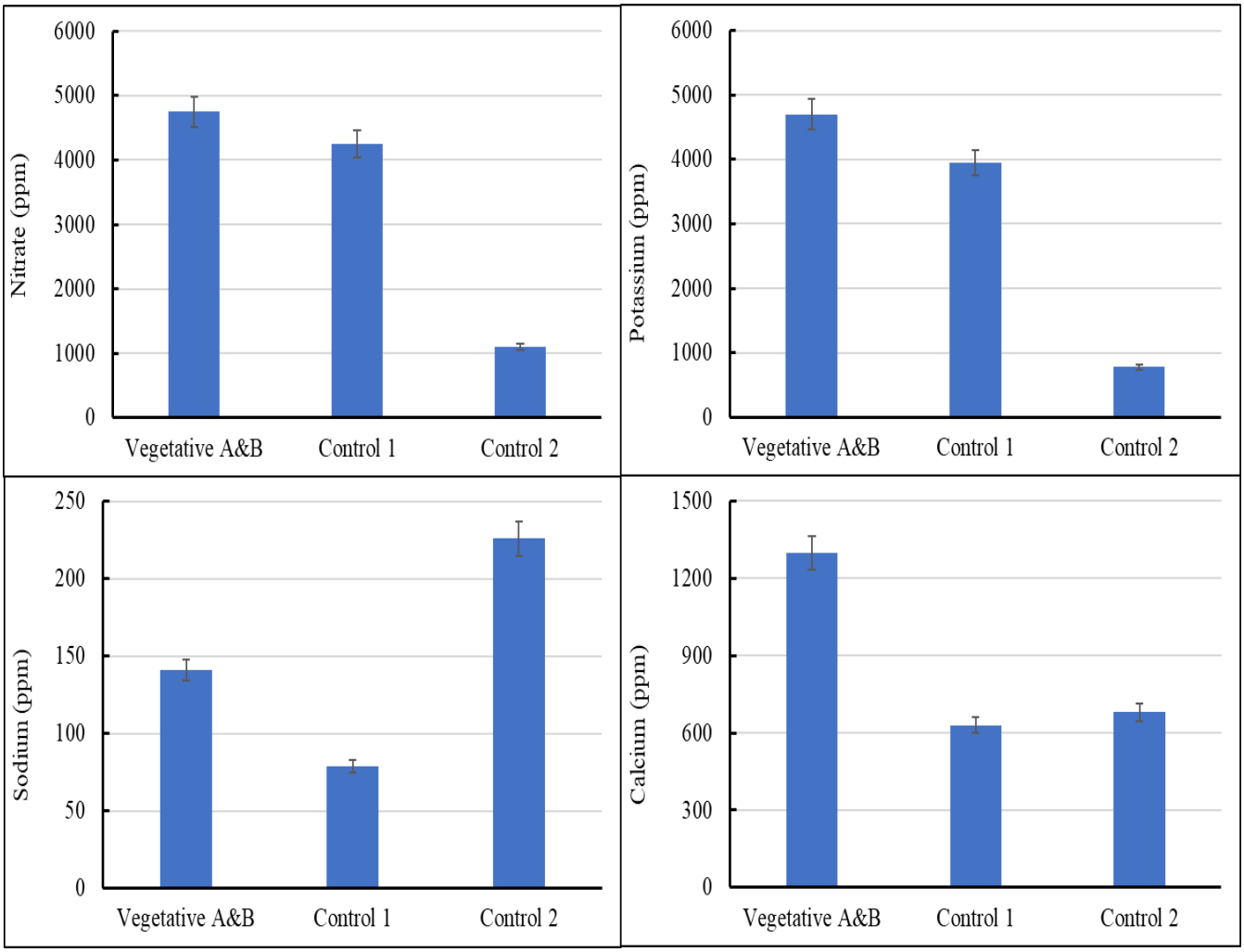

Figure 8. Nitrate, potassium, calcium and sodium content of kale as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

We did not detect calcium in the Swiss chard. However, the Vegetative A&B nutrient solution increased nitrate, potassium and sodium in the Swiss chard plants (Figure 9A-C). The sodium is not above limit.

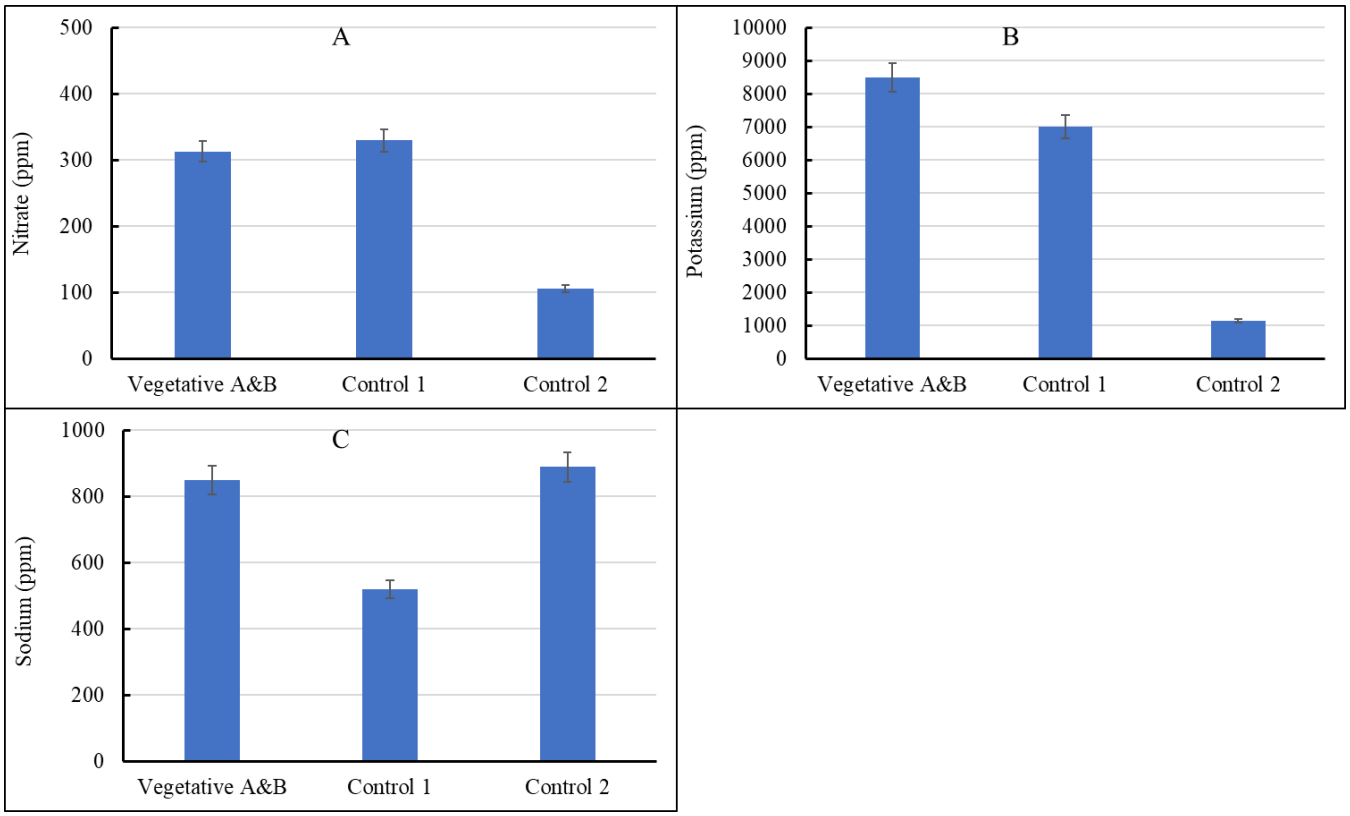

Figure 9. Nitrate, potassium and sodium content of Swiss chard as influenced by the different nutrient solutions in a hydroponic vertical tower production system.

CONCLUSION AND RECOMMENDATION

- Vegetative A&B nutrient solution proved to be superior in increasing plant shoot growth (edible portion of the three leafy greens) and yield compared to the controls under the conditions of the present study.
- Plants roots were excessive in the controls with less yield of the edible portions of the leafy greens.
- Overall, the chemical compositions (i.e., nitrate, potassium and calcium) of the leafy greens harvested from plants grown in the Vegetative A&B were increased compared to the controls.
- Plants tissues samples are being analyzed for a comprehensive nutrient analysis.
- Further studies will be required to study bioactive compounds in leafy greens using the Vegetative A&B.

REFERENCES

Baiyin, B., Tagawa, K., Yamada, M., Wang, X., Yamada, S., Shao, Y., An, P., Yamamoto, S., Ibaraki, Y. (2021). Effect of nutrient solution flow rate on hydroponic plant growth and root morphology. Plants 10, 1840. https://doi.org/10.3390/plants10091840

Dalastra, C.; Teixeira Filho, M.C.; da Silva, M.R.; Nogueira, T.A.; Fernandes, G.C. Head Lettuce Production and Nutrition in Relation to Nutrient Solution Flow. Hortic. Bras. 2020, 38, 21–26.

Sardare, M.D, Admane, S.V. (2013). A review on plant without soil-hydroponics. Int J Res Eng Technol 2(3):299–304. https://doi.org/10.15623/ijret.2013.0203013

Phibunwatthanawong, T. and Riddech, N. (2019). Liquid organic fertilizer production for growing vegetables under hydroponic condition. Intl J Recyc Organic Waste in Agric 8:369–380. https://doi.org/10.1007/s40093-019-0257-7