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Colored Benches Increase Growth, Photosynthetic Pigments, and Gas Exchange in Baby Leaf Kale

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ABSTRACT

Light quality and intensity determine the synthesis of photosynthetic pigments and gas exchange, reflecting plant growth and yield. This study evaluated growth, photosynthetic pigments, and gas exchange in baby leaf kale on colored reflective cultivation benches. In a greenhouse, we evaluated five cultivation benches with colored laminated reflective materials (Fórmicas®), representing a control bench without reflective material and benches with bright white, yellow, red, and blue reflective laminates in two production cycles. The white bench was the most effective in increasing photosynthetic active radiation in both cycles. Cultivation benches with white, yellow, red, and blue reflective material increased the number of leaves, fresh matter, dry matter, and total aerial parts concerning the control bench in both production cycles. The reflective bright blue laminate on the cultivation bench increased the chlorophyll a, b, total (a + b), and carotenoid content of baby leaf kale plants in both cycles. Using reflective materials, regardless of color, during periods of lower radiation or on a white bench at times of higher radiation increased growth, leaf productivity, and the production of photosynthetic pigments in baby leaf kale. In both cycles, the blue bench stimulated the production of photosynthetic pigments, especially carotenoids.

Introduction

Baby leaf kale can be harvested earlier than traditionally used for consumption, so the leaves are still young and not fully expanded. These vegetables are a source of health-promoting phytochemicals compared to their mature

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counterparts (Xiao et al., 2012).

Kale (*Brassica oleracea* var. Sabellica L.) has the highest antioxidant capacity among Brassica vegetables, and this is because kale is a source of phytochemicals, chlorophylls, phenolic compounds, carotenoids, ascorbate (vitamin C), anthocyanins, and glucosinates (Xiao et al., 2019; Nornberg et al., 2021). These compounds are present in kale and can reduce the risk of chronic and degenerative diseases (Zhang et al., 2025). Environmental factors such as irradiance levels and temperature can strongly influence the accumulation of glucosinolates and plant pigments (Stoewsand et al., 1995; Lefsrud et al., 2006).

Light is one such environmental factor that plays an essential role in the development and biosynthesis of pigments. The ideal light environment helps to increase photosynthesis, photomorphogenesis, and growth of plants, including horticultural crops (Kang et al., 2023; Silva et al., 2023). Most artificial plant lights have photosynthetically active radiation ranging from 400 to 700 nm.

Plant productivity changes in response to the quantity of light through photosynthesis. A specific light quality usually influences morphology, metabolism, and growth, and a correct combination of wavelengths can optimize plant production. White light increases the photosynthetic rate compared to monochromatic lighting. However, blue light promotes the accumulation of chlorophyll and carotenoids. In some species, photosynthetic capacity increases with a decrease in the red/blue ratio (Zheng et al., 2019). The concentration of carotenoids was higher in buckwheat seedlings grown under white light than in those grown under blue or red light. Blue light inhibits stem elongation in many species, ornamental and medicinal, such as chrysanthemum and stevia (Yoneda et al., 2017; Jeong et al., 2012). Adequate supplemental light improved growth, chlorophyll and carotenoid levels, photosynthesis capacity, and yield in cut roses (Davarzani et al., 2023). Sweet pepper seedlings exposed to supplemental LED light showed greater biomass, wider leaf area, and greater photosynthetic functionality (Adibian et al., 2023). However, different responses concerning light quality may depend on the species and genotype (Zheng et al., 2019).

Managing light from solar radiation for plant development can improve growth conditions in the environment. Therefore, techniques such as cultivation benches covered with reflective material aim to optimize photosynthetically active solar radiation, which reaches the benches under the leaves, providing more light energy and improving the use of this energy to carry out photosynthesis.

In this context, few studies show the effect of colored reflective benches on the growth and especially on the photosynthetic activity of plants. The effect of colored reflective benches on cherry tomatoes showed an increase in the number of fruits when grown on a red and white bench (Campos et al., 2023). However, on pepper trees (*Capsicum frutescens*), the blue, red, and aluminum reflective benches did not influence plant growth and production (Lima et al., 2018). Therefore, the mechanisms underlying the physiology and metabolism under the influence of colored reflective benches in different species require further research.

Thus, this work seeks to answer how effectively countertops with colored reflective coatings increase the biomass and growth of baby leaf kale. We hypothesize that baby leaf kale produces more chlorophyll and carotenoids when grown on blue reflective countertops. Also, countertops with reflective coatings may increase the photosynthetic efficiency of baby leaf kale. This study evaluated plant growth, photosynthetic pigments, and gas exchange in baby leaf kale on colored reflective cultivation benches.

Material and Methods

Location and characterization of the experimental area

The experiments on baby leaf kale (*Brassica oleracea* var. sabellica L.) were conducted at the State University of Mato Grosso do Sul (UEMS), Unit of Cassilândia-MS, Brazil, in two production cycles. The first cycle was from May 24 to June 29, 2022 (Cycle 1), and the second was from October 18 to November 17, 2022 (Cycle 2). The site was at latitude -19.1225º (19º07'21"S), longitude -51.7208º (51º43'15" W), and an altitude of 516 m (CASSILANDIA-A742 automatic station).

Experimental design

To produce baby leaf kale, 1.0 L pots (0.13 m diameter) spaced 0.18 m apart (Fig. 1A) were used. The pots contained Carolina Soil® substrate. Three seeds were sown per pot. After emergence, the plants were thinned out (using scissors), leaving just one plant per pot. The seedlings were irrigated twice daily, in the morning and afternoon, when necessary. Within the protected environment, the benches were 1.40 m wide x 3.50 m long x 0.80 m high. Each reflective material covered an area of 1.03 m x 1.25 m (1.28 m^2) (Fig. 1A). The benches were covered with colored laminated reflective materials (Fórmicas®), representing a control bench without reflective material, and benches with bright white, yellow, red, and blue reflective laminates (Fig. 1B).

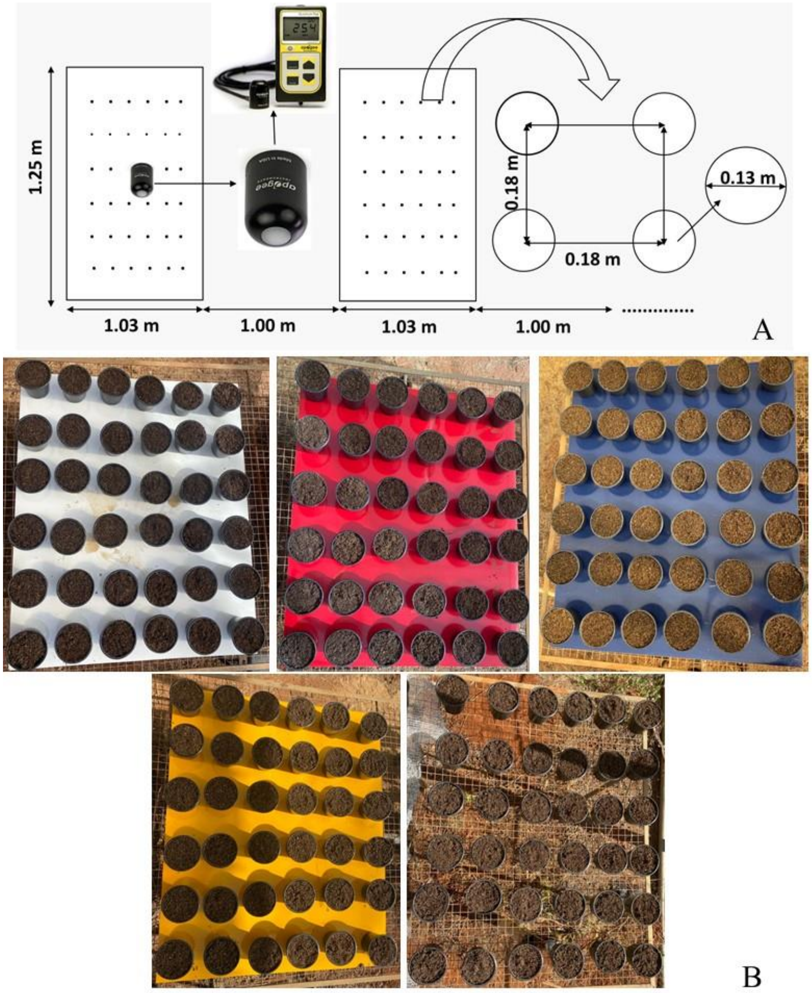

Fig. 1. Schematic representation of colored laminates, distance between them and distribution of vessels (A). Benches covered with colored laminated reflective materials representing benches with bright white, red, blue, and yellow reflective laminates, and a control bench without reflective material (B).

The reflectance spectra of the colored laminate reflective materials (Formicas®) were obtained using a UV-Vis-NIR spectrophotometer (Model Lambda 1050, Perkin Elmer) with a step of 1nm at 100 nm min^{-1}. Small discs of the laminates (diameter = 1 cm) were inserted into the sample holder of an integrating sphere with a radius of 150 mm. The reflectance spectra of the colored laminated reflective materials (Formicas®) appear in Figure 2. Blue did not have a peak in the 400-500 nm region (Fig. 2) because this blue color is probably very dark (Fig. 1B), similar to black.

The experiments were conducted in an agricultural greenhouse 18.0 m long x 8.0 m wide x 4.0 m high under a gutter (144 m^2 area), covered with 150-micron low-density polyethylene (LDPE) film, light diffuser (natural lighting), anti-drip, with a zenith opening sealed, 50% white mesh, with side and front monofilament meshes of 50% shading. Underneath the LDPE film was a 50% shading aluminized thermo-reflective mobile screen, used in the initial 30 days of cycle 1 and throughout cycle 2.

For each cultivation cycle, the experiment was carried out in a completely randomized design, with five treatments and five replications.

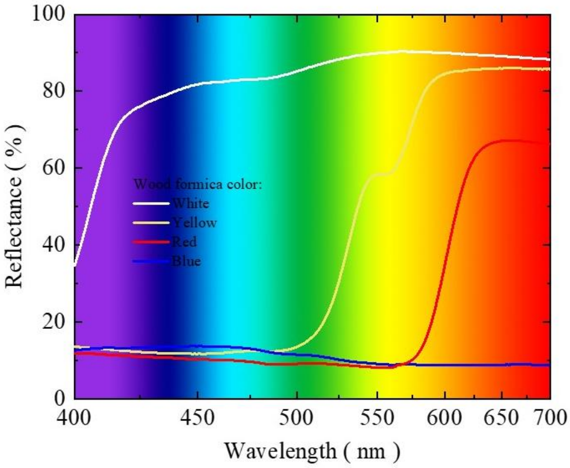

Fig. 2. Reflectance of the laminates used on the cultivation benches for the production of baby leaf kale.

Experimental conduct and data collection

The reflected photosynthetically active radiation (RPA) (µmol m-^{2} s-^{1}) of the benches was monitored with a portable digital pyranometer (Apogee®) every day at 9:30 am. The external radiation (full sun) and the internal radiation in the environment were collected with the sensor facing upwards. For the radiation reflected by the benches, the sensor faced downwards. The RPA data was compared in a randomized block design with six replications (7 days in cycle 1 and 5 days in cycle 2). The internal incident radiation was measured, considered 100%. The reflected radiation of the colors was a percentage of the internal incident radiation, being obtained by the rule of three.

When the baby leaves reached 13 to 16 cm in length, the assessments involved measuring the number of leaves (NL), plant height (PH), shoot fresh matter (SFM), shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM), and the contents of chlorophyll a (CHA), chlorophyll b (CHB), total chlorophyll (a + b) (CHT), and carotenoids (CRT). Plant heights (PH) were measured using a ruler, measuring the distance from the soil surface to the apex of the meristem stem, and counting the number of leaves (NL). Shoot fresh matter (SFM), shoot dry matter (SDM), and root dry matter (RDM) were determined using an analytical balance with a precision of four decimal places. The material was dried in an air-forced circulation oven at 65 ºC for 72 h.

Chlorophyll (a and b) and carotenoids were extracted following the method of Lichtenthaler (Lichtenthaler, 1987). A sample of 0.5 g of fresh plant material was weighed, 5 mL of 80% acetone was added, and the material was stored in 14 mL test tubes for 48 h in a refrigerator at 25 °C. After this period, the test tubes were centrifuged for 15 min at 4,000 rpm, and then the extract supernatant was diluted in a ratio of 0.3 mL of extract in 1.7 mL of 80% acetone. Measurements were made on a spectrophotometer at wavelengths 470, 647, 653, 663, and 665 nm. Three samples were used for each replication.

In the second production cycle, we measured the internal CO2 concentration (Ci), transpiration (E), stomatal conductance (gs), CO2 assimilation rate or net photosynthesis (A), water use efficiency (WUE), and instantaneous carboxylation efficiency (EiCi), using a portable infrared gas exchange meter (LCi, ADC Bioscientific, Hertfordshire, UK). The measurements were carried out at 10 am on the leaves of the middle third of the plant, with 3 readings in each reproduction.

Statistical analysis

The data were submitted to an analysis of variance, and the means were compared with the LSD test ($p \leq 0.05$).

Results

Reflected photosynthetically active radiation

The RPA under full sun conditions and in the protected environment in cycle 1 were 1,524.41 and 585.9 µmol m^{-2} s^{-1}, respectively. In cycle 2, the RPA under full sun conditions and in the protected environment were 2,014.83 and 624.79 µmol m^{-2} s^{-1}, respectively. For both cycles, the benches covered with white, yellow, and red bright laminates reflected more photosynthetic active radiation than the control (Figs. 3A and B). The bench covered with bright white laminate had the highest reflectance. The bench covered with bright white laminate increased the internal radiation incidence in the protected environment by 14.3% in cycle 1 and 22.5% in cycle 2 (Fig. 3B).

The reflected photosynthetically active radiation (RPA) (µmol m^{-2} s^{-1}) of the benches was monitored with a portable digital pyranometer (Apogee®) every day at 9:30 am (Fig. 3A). The external radiation (full sun) and the internal radiation in the environment were collected with the sensor facing upwards. For the radiation reflected by the benches, the sensor faced downwards. The RPA data was compared in a randomized block design with six replications (7 days in cycle 1 and 5 days in cycle 2) (Figs. 3A and B). The internal incident radiation was measured, considered 100% (cycle 1 was 585.9 µmol m^{-2} s^{-1} and cycle 2 was 624.79 µmol m^{-2} s^{-1}). The reflected radiation of the colors was a percentage of the internal incident radiation, obtained by the rule of three (Fig. 3B).

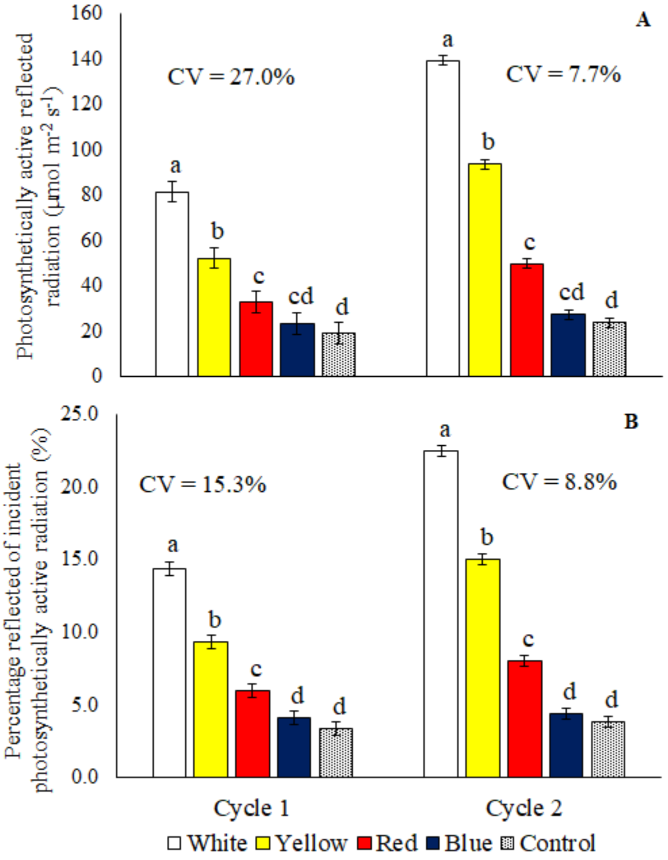

Fig. 3. Reflected photosynthetically active radiation (µmol m^{-2} s^{-1}) (A) and percentage of internal photosynthetically active radiation reflected (B) by baby leaf kale on benches in two production cycles. Cycle 1: May 23 to July 5, 2022 (A), cycle 2: October 18 to November 17, 2022 (B). CV = coefficient of variation. Bars with the same letters do not differ by the LSD test. Vertical bars indicate Standard Error.

Growth parameters

Regarding the number of leaves in cycle 1, the growth bench with reflective bright laminate led to the production of more leaves than the growth bench of the control group (Fig. 4A). In cycle 2, the number of leaves was higher on the bench covered with reflective bright white laminate when compared to the other benches and the control bench (Fig. 4B). For both cycles, the shoot fresh matter was higher in the benches with reflective bright laminate (Figs. 4A and B).

The number of leaves in cycle 1 did not vary among samples on the colored benches. However, plants on the white bench had 20.8% more leaves than the control plants (Fig. 4A). In cycle 2, the number of leaves on the white bench was significantly greater than that of the other benches, i.e., 50.0% greater than that of the control plants (Fig. 4B).

The fresh matter of the aerial part did not vary significantly among plants on the colored benches in cycles 1 and 2. However, in cycle 1, the SFM of the plants on the white bench was 48.8% higher than that of the control plants (Fig. 4A), and in cycle 2, the plants on the white bench had an SFM 215.4% higher than the control (Fig. 4B). In cycle 1, the bench with reflective white laminate increased the shoot and total dry matter, which did not differ significantly from the yellow, blue, and red laminates (Fig. 5A). In cycle 2, the white laminate led to plants with higher shoot and total dry matter than benches with blue, red, and yellow laminates and the control bench (Fig. 5B).

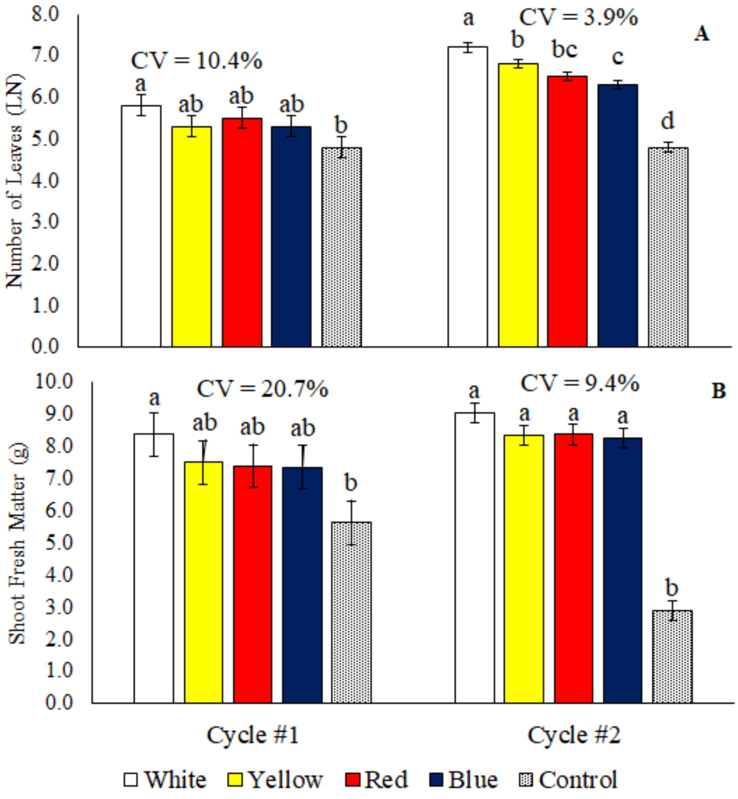

Fig. 4. Leaf number (LN) (A) and shoot fresh matter (SFM) (B) of baby leaf kale on different reflective colored growth benches in two production cycles. Cycle 1: May 23 to July 5, 2022 (A). Cycle 2: October 18 to November 17, 2022 (B). CV = coefficient of variation. Bars with the same letter do not differ by the LSD test. Vertical bars indicate standard error.

The root dry matter did not differ significantly from the control in cycle 1 (Fig. 5A). In cycle 2, the plants on the bench with yellow laminates had higher root dry matter than the benches with blue, white, and red laminates and the control bench (Fig. 5B).

The total dry matter in cycle 1 on the benches with white, yellow, red, and blue laminate increased by 37.7, 26.8, 24.8, and 15.4%, respectively (Fig. 5A). In cycle 2, the white, yellow, red, and blue laminate benches caused the plants to increase the total dry matter by 200, 154.3, 146.2, and 135.2%, respectively (Fig. 5B).

Photosynthetic pigments

The chlorophyll a content in cycle 1, in plants on the benches with blue and yellow laminates, were higher than those on the red laminate and the control (Fig. 6A). In cycle 2, the growth benches with blue and yellow laminates led to higher chlorophyll a content than those on the red laminate, white laminate, and the control (Fig. 6B). Chlorophyll a levels of kale were numerically higher in cycle 2 (107,4 µg L^{-1}) when compared to cycle 1 (63,4 µg L^{-1}). The chlorophyll a content in both cycles was higher in plants grown on the blue bench, not differing from the plants on the yellow bench. However, the chlorophyll a content in cycle 1 on the blue bench was 53.3% higher than the control plants, but was 23.0% in cycle 2. Chlorophyll b levels were also higher in cycle 2, although numerically they were similar when the kale was produced on the blue reflective bench, in both cycles, with values of 27 µg L^{-1} in cycle 1 and 34 µg L^{-1} in cycle 2. The chlorophyll b content in plants on the blue bench in cycle 1 was 56.3% higher than the control (Fig. 6A) and did not vary significantly in cycle 2 among the plants on the different benches.

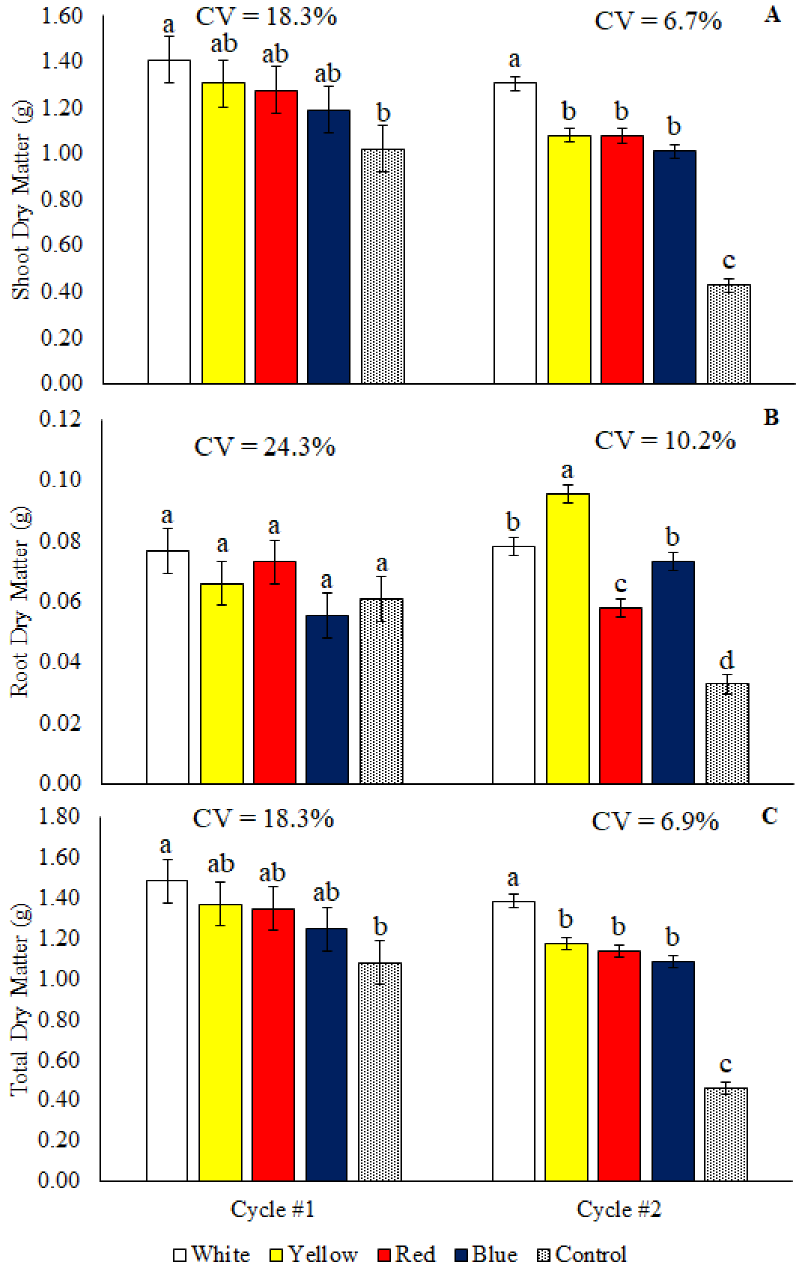

Fig. 5. Shoot dry matter (SDM), root dry matter (RDM), and total dry matter (TDM) of baby leaf kale on different reflective colored growth benches in the two production cycles. Cycle 1: May 23 to July 5, 2022 (A). Cycle 2: October 18 to November 17, 2022 (B). CV = coefficient of variation. Bars with the same letter do not differ significantly by the LSD test. Vertical bars indicate standard error.

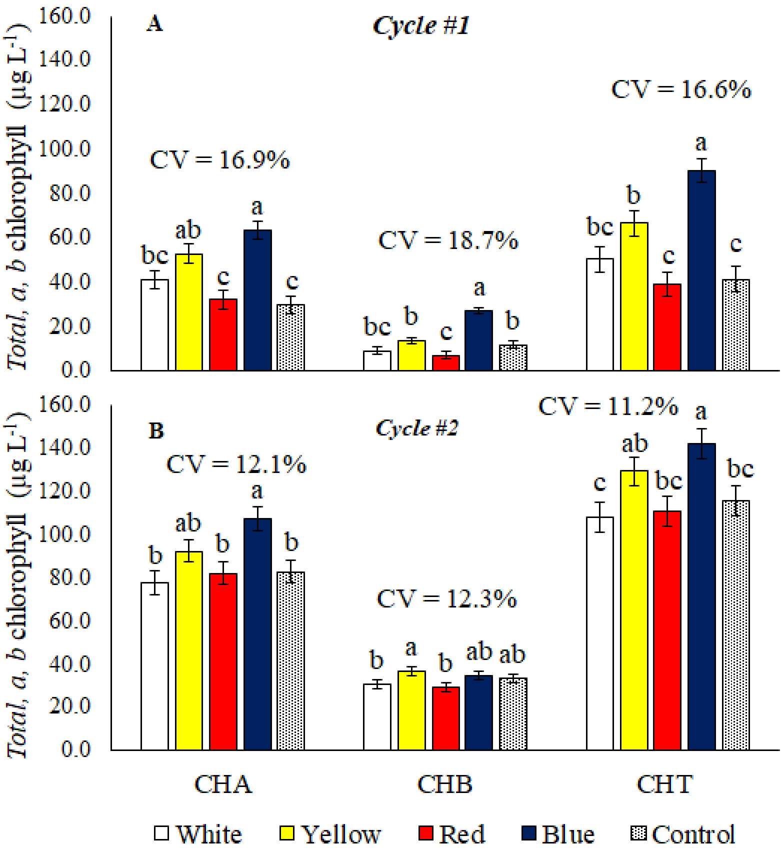

Fig. 6. Chlorophyll a (CHA), chlorophyll b (CHB), and total chlorophyll (a + b) (CHT) of baby leaf kale on different reflective colored growth benches in the two production cycles. Cycle 1: May 23 to July 5, 2022 (A). Cycle 2: October 18 to November 17, 2022 (B). CV = coefficient of variation. Bars with the same letter do not differ significantly by the LSD test. Vertical bars indicate standard error.

The total chlorophyll (a + b) content of the plants in cycle 1 was higher on the bench with blue laminate (Fig. 6A). In cycle 2, the bench with blue and yellow laminate led to higher total chlorophyll content in the baby leaf kale than in the red and white laminates and the control (Fig. 6B). Therefore, in cycle 1, CHA, CHB, and CHT increased by 114, 129, and 118% in plants on the bench with blue laminate, respectively (Fig. 5A). In cycle 2, CHA, CHB, and CHT increased by 30, 4.4, and 22.6% in plants on the bench with blue laminate, respectively (Fig. 5B), compared to the control. In cycle 1, the highest carotenoid content was found in plants on the bench with blue laminate (Fig. 7A). In cycle 2, there were no significant differences among plants on the benches with blue, yellow, and control laminates regarding the carotenoid content in the plants (Fig. 7B). The bench with blue laminate increased carotenoids by 98.2% in cycle 1 and 11.7% in cycle 2, compared to the control (Figs. 7A and B). As for chlorophyll content, plants produced more carotenoids in cycle 2, compared to cycle 1, with an average increase of 54.9%.

Gas exchange

Gas exchange assessments in cycle 2 showed that the benches did not affect intracellular CO_2 content (Fig. 8A), transpiration (Fig. 8B), stomatal conductance (Fig. 8C), and water use efficiency (WUE) (Fig. 8E). The bench with white laminate provided the highest net photosynthesis rate (-A) (Fig. 8D) and carboxylation efficiency (A/Ci) (Fig. 8F). The internal concentration of CO2 in plants was 2.0, 7.3, 8.9, and 9.5%, which was lower in those on the white bench than in those on the blue, control, yellow, and red benches, respectively. The WUE in plants on the white and blue benches was 28.6, 26.4, and 17.4% higher than the control, yellow, and red benches.

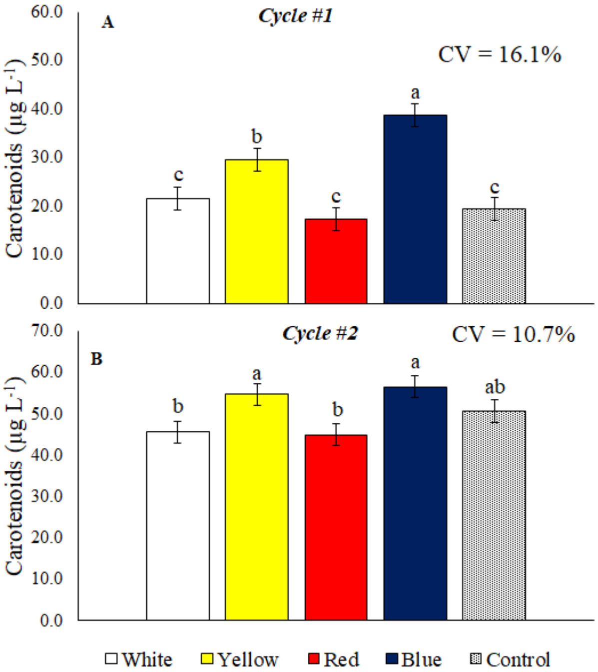

Fig. 7. Carotenoids of baby leaf kale on different reflective colored benches in two production cycles. Cycle 1: May 23 to July 5, 2022 (A). Cycle 2: October 18 to November 17, 2022 (B). CV = coefficient of variation. Bars with the same letter do.

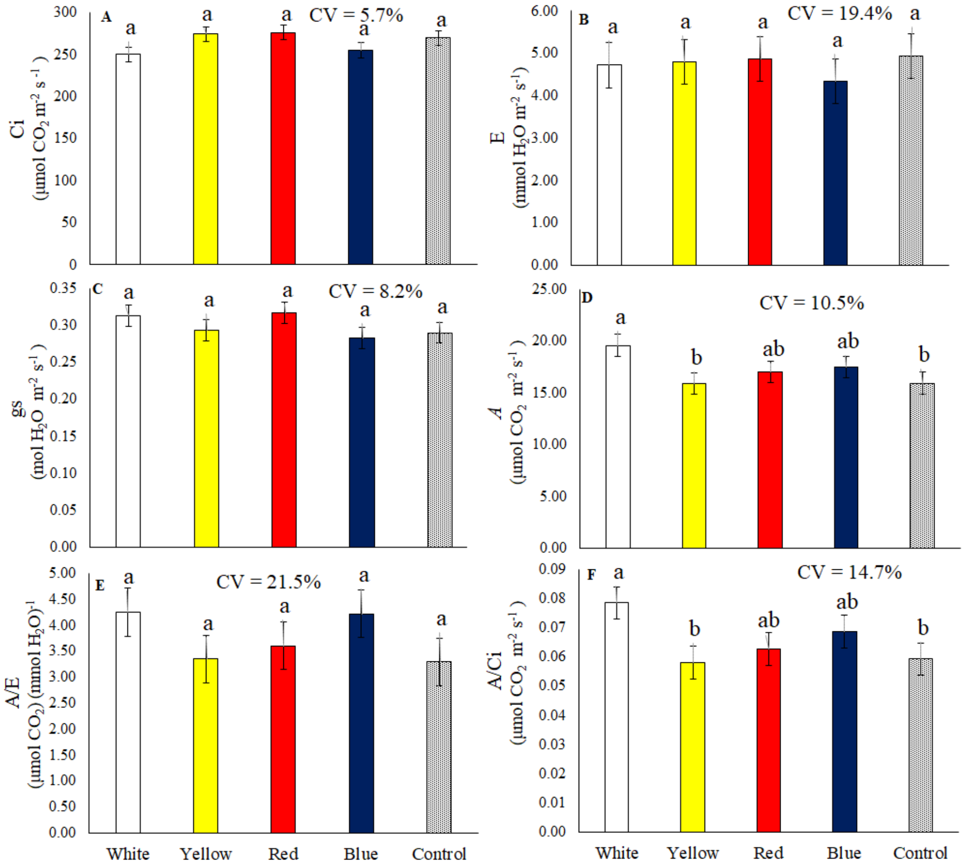

Fig. 8. Internal CO2 concentration-(Ci) (A), transpiration- (E) (B), stomatal conductance- (gs) (C), CO2 assimilation rate- (A) (D), water use efficiency- (EUA) (A/E) (E), and instantaneous carboxylation efficiency – (A/Ci) (F) of baby leaf kale on different reflective colored benches in the second production cycle (October 18 to November 17, 2022). CV = coefficient of variation. Bars with the same letter do not differ significantly by the LSD test. Vertical bars indicate standard error.

Discussion

The results of this work confirmed the hypothesis of the beneficial effect of reflective benches in increasing the growth and biomass of baby leaf kale and proved the effects of blue reflective benches in increasing chlorophyll and carotenoid concentrations. However, the results contradict the hypothesis that colored benches would increase photosynthetic efficiency since only the white bench provided significantly higher results for photosynthetic activity and intrinsic carboxylation efficiency. The plants on the other colored benches did not vary regarding the control bench. As mentioned in the literature, the incidence of photosynthetic active radiation is the micrometeorological factor that most influences plant growth in protected environments (Costa et al., 2021).

It is noteworthy that the use of reflective material on cultivation benches, according to the literature, increases photosynthetic active radiation, enabling an increase in photosynthesis in rubber tree rootstock seedlings (Costa et al., 2021). However, in the present research, the results observed for kale were more significant in the white bench, favoring growth.

Although the efficiency of photosynthetic activity of leaf kale grown on a yellow reflective bench did not remain at the same level as that of the red and blue benches, the amount of dry and fresh matter of the leaves was similar. Considering that the yellow wavelength has little influence on the excitation/absorption of photosynthetic pigments, these results suggest that the availability of light was sufficient to maintain the energy needs of the kale leaf.

The use of reflective benches for cultivation made it possible to increase the number of leaves (Fig. 4) because the laminated material, even reflecting part of the photosynthetic active radiation that reaches the cultivation benches to the leaves, the wavelengths provided in the reflection were efficient in activate the pigments that comprise photosystems I and II (chlorophylls and carotenoids). This activation provides sufficient light energy for photophosphorylation and the production of ATP and NADPH2 necessary for the next step of photosynthesis, with the production of photo-assimilates for the accumulation of leaf dry matter and the production of photosynthetic pigments. Furthermore, the reflection of leaves from colored banks provided greater availability of light energy and increased the number of kale leaves, improving their use for photosynthesis (Costa et al., 2021; Taiz et al., 2017).

It is noteworthy that the biosynthesis of chlorophyll a, chlorophyll b, chlorophyll total (a + b), and carotenoids (Figs. 6 and 7) of the baby leaf kale in this work was influenced by the quality and intensity of the light emitted by the cultivation benches. The reflection of blue light from the bench (which has a shorter wavelength) on the baby kale leaf corresponded to an increase in the production of photosynthetic pigments because the blue light photoreceptors regulate the biosynthesis of pigments, as well as phytochrome proteins that are related to red light (Zheng et al., 2019; Gupta and Karmakar, 2017; Liu et al., 2017). Thus, the increase in chlorophylls is related to the efficiency of the photosynthetic process (Dou et al., 2019). Furthermore, in some leafy crops, such as lettuce, blue light also increases the production of antioxidant compounds (phenolic acids, carotenoids, flavonoids, anthocyanins) and vitamins (Son and Oh, 2013).

It is interesting to note that kale reacted differently to blue light depending on the intensity of the radiation. Under a higher level of radiation, as observed in cultivation cycle 2, chlorophyll a had a significant increase, different from the result observed for chlorophyll b. Thus, evaluating the two cultivation cycles, the cultivation bench with bright blue reflective laminate provided an average increase of 72, 67, 70, and 55% of chlorophyll a, b, total (a + b), and carotenoids, respectively, compared to the control. The literature comments that plants under lower radiation, evaluated in the understory or seedlings grown under artificial shading, tend to receive more wavelengths in the blue range, leading to a pronounced increase in chlorophyll b (Liu et al., 2017; Hooks et al., 2021). In the production of leafy vegetables such as lettuce, radish, and spinach, the combination of red and blue light provides a beneficial effect on biomass accumulation, and the additional blue photons can aid in plant growth. However, the different relative responses to light quality may depend on the species and genotype.

Baby leaf kale can be productive in terms of photosynthetic pigments even with lower photosynthesis, as observed in plants grown in yellow and blue reflective banks. However, the cultivation bench with bright white reflective laminate was the bench that most amplified photosynthetic active radiation. Although this white laminate increased CO2 assimilation (A), the intrinsic carboxylation efficiency (A/Ci) and the number of leaves decreased. Thus, the increase was not accompanied by an increase in photosynthetic pigments (chlorophylls and carotenoids) (Fig. 8).

The lower internal CO2 concentration (Ci) arises from the fact that more of the internal CO2 was fixed by the carboxylate enzyme, which led to a higher photosynthesis rate. On the white bench, these results are attributed to the higher photosynthesis rate of the plants compared to the other benches. However, the water use efficiency (A/E) of the plants on the blue bench is attributed to the least transpiration in these plants. It is also interesting to note that the plants on the white bench numerically had the second-highest stomatal conductance and a significantly higher photosynthetic rate. However, the plants on the red bench numerically obtained the highest stomatal conductivity, and the photosynthetic rate did not vary among the plants on the other benches.

The increase in blue light caused a decrease in the growth rate in some lettuce cultivars. However, the photosynthetic capacity of lettuce leaves increased with a lower red/blue ratio (Son and Oh, 2013), which is associated with an increase in stomatal conductance (gS), together with the dry weight of the shoot, as also observed in Cucumis sativus (Wang et al., 2015).

The white laminate increased the reflectance of photosynthetic active radiation (Fig. 3), providing an increase in the fresh matter of the aerial part (Fig. 4), dry matter of the aerial part, dry matter of the root and total dry matter (Fig. 5) resulting from the greater intrinsic activity of carboxylation and CO2 assimilation (Fig. 8), which positively influenced the development of baby kale leaf. Various species have different responses to reflective benches. Thus, on average, in the two cultivation cycles, the benches with white, yellow, red, and blue laminates increased the number of leaves by 35.5, 26, 25, and 20.8%. The fresh matter of the aerial part increased by 132, 112, 112, and 109% (Fig. 4), respectively, for plants grown on benches without laminates (control).

Conclusions

It is worth mentioning that cultivation on a reflective bench, regardless of color, during periods of lower radiation or on a white bench, at times of higher radiation, increases the number of leaves and plant productivity. However, if the focus is production with an interest in bioactive compounds such as carotenoids, among others not evaluated in this work, the choice of countertop color may vary depending on the intensity of the radiation. Thus, regarding cultivation at times of lower radiation, as characterized in this work by cycle 1, cultivation is favored on a blue reflective bench. However, if cultivation occurs at times of higher radiation, the blue or yellow bench would provide similar results.

The use of reflective materials is an alternative method that provides baby leaf kale with better conditions for assimilating photosynthetic active radiation, increasing growth, leaf yield, and the production of photosynthetic pigments. In cycle 2, with greater irradiance, the white bench favored leaf growth and yield. In both cycles, the blue bench favored the production of photosynthetic pigments, especially carotenoids.

Acknowledgments

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Conflict of Interest

The authors indicate no conflict of interest in this work.

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