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Growth of *Basella alba* under different light environments

Crescimento de plantas de *Basella alba* cultivadas em diferentes ambientes de luz

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A B S T R A C T

Basella alba L. (Malabar spinach) is a non-conventional food plant (PANC) with high nutritional value and economic potential. Light is a critical factor in plant growth, acting directly on the photosynthetic process. The photoselective meshes combine the physical protection of plants with the selective filtering of solar radiation to promote physiological responses. This work evaluates the growth of *B. alba* under different light environments. The experiment occurred in a greenhouse at the Center for Agrarian, Environmental and Biological Sciences of the Federal University of Recôncavo da Bahia in a completely randomized design with plots comprising one useful plant and five replications. The plants were grown in three light environments: red ChromatiNet mesh, aluminet-thermo reflective mesh (both with 50% irradiance), and under full sun. The red mesh increased the root dry matter mass and stem diameter. The aluminet mesh increased the average number of leaves by about 50% compared to the plants cultivated under full sun. The results show that the cultivation of *B. alba* in different light environments promotes morphophysiological changes with positive increments in growth.

Palavras-chave:
Basella alba L.
Hortaliça não convencional
Qualidade spectral
Sombreamento

R E S U M O

A bertalha (*Basella alba* L.) é uma planta alimentícia não-convencional (PANC), com alto valor nutricional e de grande potencial alimentício e econômico. Dentre os fatores que influenciam no crescimento das plantas, destaca-se a luz como um dos mais importantes, visto que ela atua diretamente nos processos fisiológicos e o uso de malhas fotosseletivas nesse contexto visa combinar a proteção física das plantas, com a filtragem seletiva da radiação solar para promover respostas fisiológicas desejáveis no crescimento. Assim, objetivou-se avaliar o crescimento de plantas de bertalha sob diferentes ambientes de luz. O experimento foi conduzido em casa de vegetação do Centro de Ciências Agrárias, Ambientais e Biológicas da Universidade Federal do Recôncavo da Bahia, em delineamento inteiramente casualizado com parcelas constituídas por uma planta útil e 5 repetições. As plantas foram cultivadas em três ambientes de luz: malha ChromatiNet vermelha, malha termorefletora aluminet (ambas com 50% de irradiância) e a pleno sol. Dentre os parâmetros avaliados, observou-se que as plantas de bertalha cultivadas nos ambientes sombreados responderam à modificação do espectro luminoso proporcionado pelas malhas. O cultivo de bertalha sob malha vermelha promoveu o aumento da massa da matéria seca da raiz e diâmetro do caule. A malha aluminet favoreceu maior número médio de folhas, com cerca de 50% a mais que àquelas cultivadas sob pleno sol. Os resultados evidenciam que o cultivo de bertalha, em ambientes de luz promove alterações morfofisiológicas, podendo ser notados incrementos positivos em seu crescimento.

INTRODUCTION

Non-conventional food plants (PANCs) are native, exotic, or naturalized edible species that are not used in the diet and are generally not commercialized. They are considered weeds even though they are nutritious and easy to find, such as in the streets, woods, backyards, and gardens. However, PANCs are an alternative to vegetable consumption, providing a healthy and balanced diet.

Basella alba L. (Basellaceae) originated in Southeast Asia and India (KINUPP; LORENZI, 2014) and is considered a PANC. It is popularly known as Malabar spinach, Indian spinach, Ceylon spinach, and vine spinach. It has tender and tasty leaves, and all its parts can be used for human food in several dishes and recipes, especially as a sauté. It has high levels of vitamins (A, B9, and C), mineral salts (calcium, iron, phosphorus, and magnesium), and amino acids (arginine, isoleucine, leucine, lysine, threonine, and tryptophan) (LANA, 2010; KHARE, 2012; TOBELEM, 2018 SARTORI, et al., 2020). *B. alba* also has medicinal uses, with emollient and astringent properties (GONDIM, 2010).

B. alba can replace cabbage, spinach, and other leaves, due to its high nutritional value and similar flavor. When well cultivated, it can be marketed and contribute to varying the diet of Brazilians, especially in the Northeast region, as a food sovereignty strategy (LANA, 2010).

The cultivation of *B. alba* is suitable for hot climates (between 26 and 28 °C), in fertile soils with a high content of organic matter, and can occur asexually through vegetative cuttings (CAMPOS et al., 2012). Despite the vast food potential, this species is still poorly cultivated and studied, requiring research to investigate the best forms of cultivation to analyze the behavior of *B. alba* in different environments.

Light is a critical environmental factor, directly influencing plant development by providing energy for photosynthesis and generating signals that regulate growth. Changes in light levels induce different physiological responses in biochemical processes, nutritional characteristics, and growth, as these depend on the light presence, attenuation, absence, and also on spectral quality of the radiation (TAIZ et al., 2017).

Shading screens, also called photoconverting and thermo-reflective meshes, are a useful technological innovation in the development of plants, as they absorb light at different spectral wavelengths, favoring or reducing the photosynthetic rate. These meshes are made with high-density polyethylene film and monofilament yarns, which block the ultraviolet radiation and alter the spectrum of light that passes through them, reducing or increasing peaks of transmittance of radiation at specific wavelengths (POLYSACK, 2022). In addition, these screens increase the percentage of diffused light, favoring light coverage on plants and, consequently, affecting their physiology, morphology, and growth (SOUZA et al., 2017).

Considering the relevance of *B. alba* for human consumption and the few agronomic studies on the species, this work aims to assess the vegetative growth of this species under different light environments.

MATERIAL AND METHODS

The experiment occurred from February to May 2021 in a greenhouse belonging to the Center for Agrarian, Environmental and Biological Sciences of the Federal University of Recôncavo da Bahia, Cruz das Almas, Bahia, Brazil (200 m altitude; coordinates 12°40'0" S - 39°06'0" W). According to the Köppen classification, the region has an Aw to Am climate, tropical hot and humid, with an average annual rainfall of 1224 mm and higher precipitation from March to June.

In the production of seedlings, we used cuttings taken from a matrix plant in a rural property (Sapeaçu, Bahia). The selected cuttings comprised the middle parts of the stem containing two axillary buds. Cuttings were planted in 400 mL perforated disposable cups containing soil and earthworm humus as substrate in a 3:1 ratio.

Irrigation of cuttings was performed daily with 100 mL of water. They were placed in a greenhouse for 35 days. Then, they were transplanted into 3.0 dm^3 pots containing a mixture of 2 L of soil and 1 L of bovine manure as substrate, which underwent chemical analysis (Table 1).

The experiment comprised a completely randomized design, arranged in plots subdivided in space, consisting of one plant per pot. The plants were grown in three light environments: red Chromatinet mesh, thermo-reflective aluminet (both meshes with 50% shading), and full sun (control treatment). Five replications per treatment were used, totaling 15 experimental units, with a spacing of approximately 30 cm between pots.

Fifty-six days after transplanting, eight plant parameters were quantified. The plant height was estimated with a measuring tape graduated in millimeters from the stem to the apex of the terminal bud. The indices of chlorophyll a, chlorophyll b, chlorophyll a/b ratio, and total chlorophyll (ICF – Folker Chlorophyll Index) were measured between 6:00 and 8:00 am, using the Falker Chlorophyll Meter model - CFL1030, with readings performed on three leaves of the middle third of each plant. The number of leaves was recorded by simple counting. The diameter of the plant neck was measured with an analog caliper, measuring the base of stem. A tape measure was used to measure the root length. The results of lengths and diameters were expressed in millimeters.

The yield was evaluated by weighing the fresh mass of leaves and the dry mass of the leaves, roots, and stems. Fresh leaves were weighed on a digital scale. Then, the plant material (partitioned into root, stem, and leaves) was placed in kraft paper bags, identified, and dried at 65 °C in an air circulation oven for 72 hours until reaching dry weight stability. The results were expressed in grams.

Leaf area was estimated using a 6 mm diameter perforator, collecting ten leaf discs from each plant in randomly chosen leaves and avoiding the midrib regions. The discs were dried under the conditions mentioned above and weighed on a 10e-4 precision analytical balance. Values of dry matter mass and area of the 10 discs enabled the estimative of leaf area. Leaf area ratio, leaf mass ratio, and specific leaf area were calculated using mathematical formulas described by Peixoto et al. (2011).

Data were subjected to analysis of variance using the R statistical program (R CORE TEAM, 2018), followed by Tukey's test, at a 5% significance level to compare means.

RESULTS AND DISCUSSION

Plants of *B. alba* grew significantly more in environments with shading-controlled lighting than under the full sun. However, there were no significant growth changes between the different mesh colors (Table 2).

Table 1. Chemical characteristics of yellow oxisol and cattle manure collected in Cruz das Almas, Bahia, Brazil.

Chemical characteristics	pH	P	K	Ca^{2+}	Mg^{2+}	H+Al	CTC(t)	CTC(T)	V	OM
	H_2O	.... mg/dm^3		.... Cmol(c)/dm^3					.... %	
Soil 0-20 (cm)	6.3	18.6	70.2	3.0	2.2	4.8	5.4	10.2	53.0	3.0
Cattle manure	7.7	287.7	2316.6	20.0	3.8	1.2	29.7	30.8	96.0	8.5

Although not statistically significant, plants under meshes grew more than plants under full sun, overpassing three meters in height. This growth may be due to the 50% reduction in irradiance level, forcing plants to invest in cell elongation under these conditions. Taiz et al. (2017) suggest that light limitation causes stem elongation, which shows the plants' ability to adapt to shaded environments.

B. alba plants grown under aluminet mesh had about 50% more leaves than those grown in full sun and red mesh (Table 2). These results suggest that shaded environments benefited plants, reducing solar radiation and heat stress, which allowed them to focus energy on leaf production.

Table 2. Plant height, number of leaves, leaf area, specific leaf area, leaf area ratio, leaf mass ratio, root growth, stem diameter, and fresh leaf mass of *Basella alba* plants submitted to different light environments.

Variables	Light environments			
	Red mesh	Aluminet mesh	Full sun	CV (%)
Plant height (cm)	350 a	372 a	233 b	17.55
Root growth (cm)	34.26 a	34.12 a	27.76 b	14.9
Leaf area (cm^2)	24.58 a	25.91 a	30.62 a	24.09
Specific leaf area ($cm^2\ g^{-1}$)	1.81 b	1.86 b	2.73 a	19.84
Leaf area ratio ($cm^2\ g^{-1}$)	0.64 b	0.72 b	1.04 a	21.17
Leaf mass ratio ($cm^2\ g^{-1}$)	0.35 a	0.38 a	0.38 a	6.11
Number of leaves (un)	136.4 b	186.6 a	123.6 b	16.09
Stem diameter (mm)	12.42 a	9.90 b	8.80 b	12.62
Fresh leaf mass (g)	13.15 a	206.14 a	161.14 b	6.14

*On the line, averages followed by the same letters do not differ statistically according to Tukey's test at 5% significance.

Mesh colors also influenced basil (*Ocimum basilicum*) growth (PAULUS et al., 2016). Basil plants grown under aluminet mesh showed greater height growth than those grown in full sun. Also, Ora-pro-nóbis plants (*Pereskia aculeata*) had a higher number of leaves when grown under meshes (FERREIRA et al. 2021)

Lettuces (*Lactuca sativa*) also performed better in shaded crops (SANTOS et al., 2009). In this case, the meshes were fundamental to obtaining greater productivity because the high temperatures prevent the growth of leaves. Broccoli (*Brassica oleracea*) developed more leaves when grown under shading nets (BHERING, 2013). Parsley (*Petroselinum crispum*) also showed better development under shading screens (NOHAMA et at., 2011).

Leaf area and leaf mass ratio did not differ between treatments (Table 2), so light environments did not significantly interfere with these variables. However, Lima et al. (2018) found a higher leaf area and leaf mass ratio in crops of *Lippia alba* under the aluminet mesh. This divergent result can be due to the characteristics of the studied plant species.

The spectral quality of radiation in *B. alba* plants affected the physiological growth, resulting in higher values of specific leaf area and leaf area ratio in plants grown under full sun. Peppermint plants (*Mentha × piperita*), when grown in the aluminized mesh, also showed a reduction in the leaf area ratio with increasing shading (COSTA et al., 2014). The decrease in this variable may demonstrate an inability of plants to grow in low light, presenting a lower proportion of photosynthetically active tissue.

The *B. alba* plants grown under the meshes had about 22% longer roots than those grown under the full sun (Table 2). Ora-pro-nóbis plants did not demonstrate an increase in root length between red and black meshes (JESUS et al., 2020). However, these authors verified that the ora-pro-nóbis grown without shading had longer roots, which can be explained by the plants' strategies to explore the deeper layers of the substrate in search of water since, in this warmer environment, there was greater evaporation of water compared to shaded environments. Such results differ from those found in the present work.

Plants grown under the red mesh showed larger stem diameters (Table 2). This variable provides better support for the aerial part of the plant since *B. alba* has many lateral branches and leaves. In addition, the leaves' fresh mass was higher in the plants under the meshes, which probably required a more structured stem to convey the sap to the leaves with better efficiency.

Plants grown under aluminet and red meshes showed significantly higher values of the dry mass of leaves, stem, shoot, and total mass compared to plants grown in full sun, except for the dry mass of root (Table 3). These results demonstrate that B. alba plants prefer shady environments, being undemanding for specific wavelengths, as high radiation or direct exposure to the sun hampered their growth. This species presents greater growth when cultivated in shading, as they invest the partition of their assimilates to the different parts of the plant, increasing productivity.

Table 3. Leaf dry mass (MSF), stem dry mass (MSC), shoot dry mass (MSPA), root dry mass (MSR), total dry mass (MST), and root to shoot dry mass ratio (MSR/MSPA) of *Basella alba* plants subjected to different light environments.

Variables (g)	Light environment			CV (%)
	Red mesh	Aluminet mesh	Full sun	
Leaves dry mass	13.42 a	13.84 a	11.1 b	5.80%
Stem dry mas	17.378 ab	18.382 a	15.108 b	8.34%
Shoot dry mass	32.255 a	30.839 a	26.230 b	5.67%
Root dry mass	7.278 a	3.558 b	2.904 b	28.99%
Total dry mass	38.117 a	35.813 a	29.134 b	5.91%
Root to shoot dry mass ratio	0.23 a	0.11 b	0.11 b	30.51%

*On the line, averages followed by the same letters do not differ statistically according to Tukey's test at 5% significance.

The dry mass parameters of Lippia alba plants, grown in shaded environments with red meshes and aluminet, also show significant and similar differences with those of this research (LIMA et al., 2018). Dry mass and height express plant productivity and growth well, as these variables show positive increments in good environmental conditions and other factors (TAIZ et al., 2017).

Plants grown under the red mesh had higher root dry mass than those grown under the aluminet grid and full sun (Table 4). Plants of ora-pro-Nobis and lemon balm (*Melissa officinalis*) grown under red meshes also obtained higher gains in root dry mass than those under the full sun (BRANT et al., 2009; VIEIRA et al., 2019).

Unlike the result found in our work, basil plants grown under the full sun have higher values of fresh and dry mass of roots without the influence of colored nets (PAULUS et al., 2016). On the other hand, oregano plants (*Origanum vulgare* L.) cultivated with colored nets increased their root dry mass, shoot dry mass, and total dry mass, especially under blue and red nets (OLIVEIRA et al., 2017). Such results are related to the greater contribution of photons in the region between red and far-red of the electromagnetic spectrum, which interferes in physiological and morphological processes, suggesting stimuli for growth and vegetative vigor, stomata opening, alterations in phytochrome and chlorophylls.

The quality of light potentiates the photosynthetic process. For example, modifications of the incident radiation stimulate the increase in total dry mass of guaco (*Mikania glomerata*), showing the phenotypic plasticity of this species (BRITO et al., 2020).

The ratio of root mass to shoot mass in B. alba plants grown under red mesh was significantly higher than in the other treatments. The higher this ratio, the greater the difference between root and shoot mass, indicating greater mass distribution and conduction of the photoassimilates flow towards the root system.

The positive performance of the root dry mass of plants grown under mesh suggests that light environments contribute to the displacement of photoassimilates inside the plants, stimulating cell division, favoring the growth of the root system and, consequently, the absorption of water and nutrients. by the roots (BRANT et al., 2009; SOUZA et al., 2010; OLIVEIRA et al., 2017; LIMA et al., 2018; BRITO et al., 2020). However, Martins et al. (2008), studying *Ocimum gratissimum* L., found a contrasting result to this research, in which plants grown under full sun showed greater allocation of dry mass to the root.

Plants grown under full sun showed significantly higher values of chlorophyll a, b, and total than shaded plants (Table 4). On the other hand, these indices did not differ between the two types of shading. Direct solar radiation in plants ensures greater efficiency in the absorption and transfer of energy for the photosynthetic process (BRITO et al., 2020).

Table 4. Chlorophyll *a* (CLA), *b* (CLAB), total (CLT), and *a*/*b* ratio (CLA/CLAB) indices in *Basella alba* plants submitted to different light environments.

Variables	Light environment			CV (%)
	Red mesh	Aluminet mesh	Full sun	
Chlorophyll *a*	34.894 b	36.928 b	45.894 a	5.92%
Chlorophyll *b*	12.180 b	14.972 b	23.194 a	17.6%
Chlorophyll total	47.074 b	51.900 b	68.222 a	9.12%
Chlorophyll *a*/*b* ratio	2.870 a	2.468 a	2.011 b	10.52%

*On the line, averages followed by the same letters do not differ statistically according to Tukey's test at 5% significance.

The chlorophyll *a* content was about 30% higher in plants grown under full sun than those grown under the red mesh, which showed the lowest value. This type of chlorophyll is present in photosynthetic organisms, comprising the essential pigment in the photochemical phase for organic substances production. The other pigments, such as chlorophyll *b* and carotenoids, help in light absorption and transfer this energy to the reaction centers. Both chlorophylls play different roles in plants and absorb the energy of different wavelengths. The chlorophyll content is an indicator of biomass production, aiding in evaluating the performance of the photosynthetic activity (TAIZ et al., 2017).

Guaco plants grown in light environments show results contrary to this research, as those grown under aluminet and red meshes had higher values of chlorophyll *a*, *b*, and total (BRITO et al., 2020). However, plants grown in full sun generally have higher chlorophyll contents because the amount of solar radiation influences plants' metabolism and the quality of light that reaches the photochemical reaction center to excite chlorophyll.

Larcher (2004) states that plants exposed to high radiation have a more active metabolism with thicker leaves, and grow even more in shaded environments. Under light limitation, plants grow avoiding the shade towards the light but with a questionable growth quality (TAIZ et al., 2017).

B. alba plants grown in shaded environments showed higher values of chlorophyll a/b ratio (Table 4), demonstrating a reduction in the variation between chlorophylls a and b, in which chlorophyll a had a higher increase than chlorophyll b, suggesting the importance of shading for B. alba plants. It should also be noted that the increase in the chlorophyll index generated a decrease in the a/b ratio.

CONCLUSIONS

Shaded environments favor the accumulation of phytomass in *B. alb*a plants.

B. alba grown in full sun have higher leaf areas and chlorophyll contents.

The red Chromatinet mesh positively affects the growth and production of *B. alba* plants in terms of root dry mass and stem diameter.

The aluminet Thermo reflective mesh promotes an increase in the number of leaves and stem dry mass.

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REFERENCES

BHERING, A. S. Efeito das malhas termorefletora, difusora e sombrite no crescimento e produtividade do brócolis. Dissertação, Universidade Federal de Viçosa, Viçosa, 2013, 39p.

BRANT, R. S.; PINTO, J. E. B. P.; ROSA, L. F.; ALBUQUERQUE, C. J. B.; FERI, P. H.; CORÊA, R. M. Crescimento, teor e composição do óleo essencial de melissa cultivada sob malhas fotoconversoras. Ciência Rural, 39 (5): 1401-1407, 2009. 10.1590/S0103-84782009005000083

BRITO, G. S.; CARVALHO, W. S.; SOUZA, G. S.; ALMEIDA, V. G. S.; SANTOS, A. R.; LIMA, J. C.; Crescimento e anatomia foliar de *Mikania glomerata* cultivadas em diferentes ambientes de luz. In: ZUFFO, A. M.; AGUILERA, J. G. (eds). Agronomia: avanços e perspectivas. Mato Grosso: Pantanal editora, 2020, p.06-16. 10.46420/9786599120862

CAMPOS, R. A. S.; LIMA, G. P. P.; SEABRA, S. J.; TAKATA, W. H. S.; SILVA, E. G. Crescimento e desempenho de bertalha (*Basella alba* L.) em função do tipo de propagação. Revista Caatinga, 25 (4): 11-18, 2012.

COSTA, A. G.; CHAGAS, J. H; BERTOLUCCI, S. K.; PINTO, J. E. B. P. Níveis de sombreamento e tipos de malha no crescimento e produção de óleo essencial de hortelã-pimenta. Horticultura Brasileira, 32 (2): 194-199, 2014. 10.1590/S0102-05362014000200013.

FERREIRA, P. M; SOUZA, S. S.; BRITO, G. S.; LIMA, J. C.; SANTOS, A. R. *Pereskia aculeata* sob ambientes de luz. In: D'Ávila, L. S. SANTOS, N. M.; RAMOS, Y. C.; SILVA, L. F.(org.). Agronomia: pesquisas técnico-científicas no Recôncavo da Bahia. Cruz das Almas, BA: EDUFRB, 2021. P. 12-140.

GONDIM, A. (Ed.). Catálogo brasileiro de hortaliças. Brasília: Alpha Gráfica e Editora, 2010.

JESUS, R. S.; ANJOS, G. L.; FERREIRA, P. M.; JESUS, A. R.; SOUZA, G. S.; SANTOS, A. R. Características agronômicas de ora-pro-nóbis cultivadas em ambientes de luz e adubação orgânica. Brazilian Journal of Development, 6 (3): 15048-15063, 2020. 10.34117/bjdv6n3-397

KHARE, C. P. Indian medicinal plants: an illustrated dictionary. Calcutta: Springer Science Business Media, 2012

KINUPP, V. F.; LORENZI, H. Plantas alimentícias não convencionas (PANC) no Brasil: guia de identificação, aspectos nutricionais e receitas ilustradas. Nova Odessa: Instituto Plantarum, 2014.

LARCHER, W. Ecofisiologia vegetal. São Carlos: Rima Artes e Textos, 2004, 531p.

LANA, M. M. 50 Hortaliças: como comprar, conservar e consumir. Brasília: Embrapa Hortaliças, 2010. Disponível em: http://ainfo.cnptia.embrapa.br/digital/bitstream/item/212740/1/50-HORTALICAS-COMO-COMPRAR-CONSERVAR-E-CONSUMIR.pdf>. Acesso em: 17 jun. 2021.

MARTINS, J. R.; ALVARENGA, A. A.; CASTRO, E. M.; PINTO, J. E. B. P.; SILVA, A. P. O. Avaliação do crescimento e do teor de óleo essencial em plantas de *Ocimum gratissimum* L. cultivadas sob malhas coloridas. Revista Brasileira de Plantas Medicinais, 10 (4): 102-107, 2008.

LIMA, J. C.; OLIVEIRA, U. C.; SANTOS, A. R.; SOUZA, A. A.; SOUZA, G. S.; Proporções de amônio e nitrato no crescimento de plantas de *Lippia alba* (Mill) N. E. Br. cultivadas sob ambientes de luz. Revista de Ciências Agrárias, 41 (3): 655-662, 2018. 10.19084/RCA17240

NOHAMA, M. T. R; RODRIGUES, L. F. O. S.; JUNIOR, S. S.; SILVA, M. B.; OLIVEIRA, R. G.; NUNES, M. C. M. Desempenho de salsa sob diferentes telas de sombreamento. Horticultura Brasileira, 29 (2): 103-109, 2011.

OLIVEIRA, V. C.; SANTOS, A. R.; SOUZA, G. S.; SANTOS, R. M. Respostas fisiológicas de plantas de orégano (*Origanum vulgare* L.) cultivadas sob malhas coloridas e fertilizantes orgânicos. Revista Colombiana de Ciências Hortícolas, 11 (2): 400-407, 2017. 10.17584/rcch.2017v11i2.7591

PAULUS, D.; VALMORBIDA, R.; FERREIRA, S. B.; ZORZZI, I. C.; NAVA, G. A. Biomassa e composição do óleo essencial de manjericão cultivado sob malhas fotoconversoras e colhido em diferentes épocas. Horticultura Brasileira, 34 (1): 46-53, 2016. 10.1590/S0102-053620160000100007

PEIXOTO, C. P.; CRUZ T. V.; PEIXOTO, M. F. S. P. Análise quantitativa do crescimento de plantas: Conceitos e Prática. Enciclopédia Biosfera 7(13):51–76, 2011.

POLYSACK INDÚSTRIAS Ltda. Malhas termorefletoras aluminizadas. Disponível em: http://www.polysack.com. Acesso em 06 de jul de 2022.

R CORE TEAM. A language and environment for statistical computing. R Foundation for Statistical Computing, 2018. Disponível em: <https://www.R-project.org/>. Acesso em: 7 ago. 2021.

SARTORI, V. C.; THEODORO, H.; MINELLO, L. V.; PANSERA, M. R.; BASSO, A.; SCUR, L. Plantas alimentícias não convencionais: resgatando a soberania alimentar e nutricional. Caxias do Sul, RS: Educs, 2020.

SANTOS, C. L.; SEABRA JR. S.; GADUM DE LALLA, J.; THEODORO, V. C. A.; NESPOLI, A. Desempenho de cultivares de alface tipo crespa sob altas temperaturas. Horticultura Brasileira, 27 (2): 3157-3162, 2009.

SOUZA G. S., CASTRO E. M, SOARES A. M, PINTO, J. E.B. P. Características biométricas e fisiológicas de plantas jovens de *Mikania glomerata* Sprengel e *Mikania laevigata* Schultz Bip. ex Baker cultivadas sob malhas coloridas. Revista Brasileira de Biociências, 8(4): 330-335, 2010.

SOUZA, G. S.; LIMA, J. C.; SANTOS, A. R.; OLIVEIRA, U. C.; BEZERRA, M. N. Produção de fitomassa de *Salvia officinalis* L. cultivada sob malhas coloridas e doses de esterco avícola. Revista Verde de Agroecologia e Desenvolvimento Sustentável, 12, (2): 182-186, 2017. 10.18378/rvads.v12i2.4213

TAIZ, L.; ZEIGER, E.; MOLLER, I. M.; MURPHY, A. Fisiologia e desenvolvimento vegetal. 6ed. Porto Alegre: Editora: ArtMed, 2017, 888p.

TOBELEM, J. A. Perspectivas para o cultivo orgânico da bertalha (*Basella alba* L.) no Cinturão Verde do município de Belo Horizonte/MG. Dissertação, Universidade Federal Rural do Rio de Janeiro, Seropédica, 2018.

VIEIRA, J. S.; MEGGUER, C. A.; CAVALCANTE, U. R.; PEREIRA, F. D.; VILARINHO, M. S. Desenvolvimento e teor de proteína em ora-pro-nóbis influenciados por diferentes condições de luminosidade. Revista Brasileira de Agropecuária Sustentável, v.9, n.4, p.27-33, 2019. 10.21206/rbas.v9i04.8242.