USE OF DIFFERENT ARTIFICIAL LIGHTING SPECTRA WITH LEDS IN INDOOR PRODUCTION OF ARUGULA MICROGREENS *(Euruca sativa)*

Abstract

Microgreens are forms of production and consumption of plant foods in their early growth phase that add maximum efficiency to the production process. The use of this crop has been used in large urban centers, in places with low luminosity, being the main problem was the choice of an adequate source of lighting for the production of microgreen in vertical urban farms. The objective of this work was to evaluate the use of different sources of artificial lighting with LED in the indoor production of arugula (Euruca sativa) microgreen. Six treatments were evaluated, namely: 1. Three 50w cold white Led boards (3BF), 2. Three 50w warm white Led boards (3BQ), 3. Three 50w full spectrum Led boards (3FS), 4 Two 50w full spectrum Led boards, and one 50w cold white Led board (2FS + 1BF), 5. One 50w full spectrum Led boards, one 50w cold white Led board and one 50w warm white Led board (FS + BF + BQ), 6. For ambient lighting (Control), the parameters analyzed were Fresh weight of shoot (FWS in g) and Dry weight of shoot (DWS in g). The use of different artificial lighting sources with LEDs increased the mass production of indoor cultivation of arugula microgreens, which demonstrates greater efficiency for plant growth, with the sources (3BQ), (3BF), and (1FS + 1BF + 1BQ), showing the best result in the development of arugula microgreens, thus generating greater aerial part mass in plants.

Keywords: *Brightness; Seedlings; Growth.*

INTRODUCTION

The growing world population has been demanding a greater amount of food, which has led to innovations in the form of production. In addition to the technological changes introduced in food production, new forms of production were also added, aiming to make food production viable in the vicinity of places of consumption. Thus, production in greenhouses, hydroponic production, and*indoor*production.*Indoor*production, that is, indoors, is the technique that allows the urbanization and verticalization of agricultural production, inside houses or vertical buildings [1].

The possibility of growing food quickly, simply, and closely to the consumer center is relevant to providing food to a population increasingly concentrated in cities. Some densely populated metropolises deal with the difficulty of seeking food in the field to meet their needs, which represents a loss of up to 60% in fruits and vegetables, which perish along the way.Producing in the urban centers themselves represents a financial, strategic, and quality gain for food [2].

In large population environments, as natural light is scarce or non-existent, it is necessary to resort to artificial lighting to stimulate metabolic processes, such as photosynthesis. There are many possible solutions to provide artificial lightings, such as the use of incandescent, fluorescent lamps, and lamps that produce light from the heating of sodium or mercury vapor, among others.Recently, LED lamps, which are adjustable electronic components, have come up with several advantages, such as the generation of luminosity in waves compatible with the specific needs of plants [3].

A trend in times of high technology is to produce alternative foods, different from those consumed until then by people. New foods need to be practical, fast-produced, natural, tasty, and highly nutritious, as is the case with *microgreens*[4]. *Microgreens are*forms of production and consumption of plant foods in their early growth phase that add maximum efficiency in the production process, diversification of food sources, and economic viability, as they offer the consumer an innovative variety of plant foods[5].

Therefore, the need to choose the appropriate source of artificial lighting for the production of *microgreens* in urban vertical farms. Thus, it is necessary to collect information in the literature about the needs and characteristics of the production of arugula *microgreen*, as well as the specificities of this type of production and lighting needs for effective and economically viable production.In this perspective, the research is justified from the perspective of economic importance, knowing that its production is required a high investment in infrastructure and agricultural insums.

Therefore, with*indoor cultivation*, these plants would be free from contact with pest organisms and diseases, in addition to continuously receiving irradiance, which would cause an uninterrupted process of photosynthesis, resulting in rapid and effective growth. Meanwhile, this study aimed to evaluate the use of different sources of artificial lighting with LEDs in the indoor production of arugula microgreen (*Euruca sativa*).

MATERIAL AND METHODS

The work was carried out in a closed compartment in the city of Anápolis, Goias. For the implementation of the experiment, we used the randomized block design, composed of six treatments and five replications, which correspond to each combination of panel lamps and the control (Table1).

TABLE1. COMPOSITION OF LIGHTING PANELS.

Panels	**Tratamentos**
1º Panel	3 Super Power Led Cob 50w 220v Cold White 6000k **(3BF)**
2º Panel	3 Super Power Led Cob 50w 220v White Hot 3000k - 3500k **(3BQ)**
3º Panel	3 Super Power Led Cob 50w 220v Full Spectrum Grow 380-840nm **(3FS)**
4º Panel	2 Super Power Led Cob 50w 220v Full Spectrum Grow 380-840nm + 1 Super Power Led Cob 50w 220v Cold White 6000k **(2FS+1BF)**
5º Panel	1 Super Power Led Cob 50w 220v Full Spectrum Grow 380-840nm + 1 Super Power Led Cob 50w 220v Branco Frio 6000 + 1 Super Power Led Cob 50w 220v White Hot 3000k - 3500k (**1FS+1BF+1BQ)**
6° Panel	Control with Ambient Lighting **(TEST)**

The automatic lighting system was controlled by a Digital Bus Timer, performing the cycle of 16 hours of lighting and 8 hours without lighting, being a Light/Dark cycle.Para to record the variations in the climate of the environment, a hygrometer was used to verify the humidity and temperature to which the treatments were submitted.

Sowing

For each treatment, a tray ofthe dimension of 17 x 13 cm wasused for each repetition, filled with 0.25 L of the uniformly homogenized substrate, taking into account the proportion of 1:1:2:1, according to the composition described in Table 2

TABLE 2. SUBSTRATE COMPOSITION.

Substrate
10 Liters of Perlita
5 Liters of Coconut Fiber
5 Kg of Peat Sphagnum
3 Kg coconut fiber powder
15 Grams of Mineral Fertilizer 2-15-10

Sowing was performed with 3.0 g of seeds, representing 590 seeds per tray, totaling 15 g per treatment, weighed with a precision scale. After sowing the substrate was watered with two commercial nutrient solutions: Arugula 1, which contains in its composition N (6%),P_2O_5 (9%),K_2O (29%),S (5%),Fe (0,2%),Ni (0,006%),Co (0,002%),Mo (0,01%),Mn (0,05%),B (0,05%),Zn (0,02%)and Mg (2,7%);Arugula 02,that presents N (14%),Ca (13%),Mg (1,3%),following the manufacturer's recommendations and the proportional calculation was carried out to make two applications, the first after sowing with half the manufacturer's recommendation (21g), to avoid damage to plants, and at 15 days after sowing with a recommendation of 42.5 g.To verify and regulate the pH of the nutrient solution, the pocket pHmeter AK90 was used, and from the result, the pH was adjusted to 6.0 according to the cultivation recommendation of the crop.

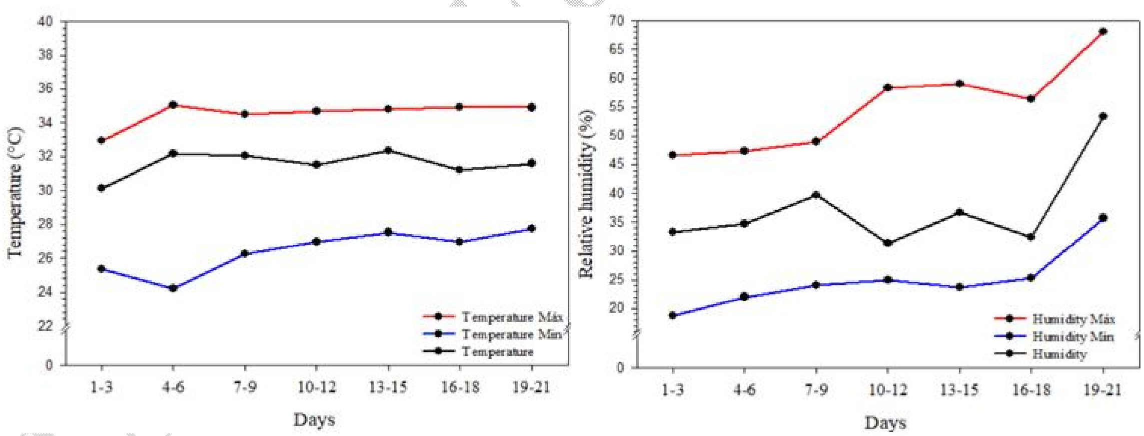

Figure 1. Temperatures and humidities were observed throughout the experiment.

Air temperature and humidity were monitored during the experiment but were not artificially controlled, so the whole experiment occurred at room temperature and humidity (Figure 1).The substrate, nutrition, and soil moisture were controlled throughout the experiment. It was observed that the ambient temperature varied during the conduction of the experiment, presenting average temperatures from 30.1 to 32.3°C, with a maximum of 35°C and minimum of 24.2°C and humidity ranging from 31.3 to 53.3%, with a maximum of 68% and a minimum of 18.6%.

The evaluations were carried out 21 days after sowing, with the following characteristics determined: Fresh weight of shoot (FWSing): measured on a semi-analytical scale (0,001 g); andDry weight of shoot (DWSin g):

where the microgreens were washed under running water, being packed in identified paper bags, and later, the material was dried in a forced-air circulation oven at 65 °C for 72 hours, and then weighed on a semi-analytical scale (0.001g) to determine its dry mass.

StatisticalAnalysis

The results obtained were submitted to variance analyses (ANOVA) and the means were compared by the Duncan test ($P \leq 0.05$), using *the* Software Sisvar version 5.6 [6]. The graphics were plotted using *sigmaplot software* version® 10 [7].

RESULTS AND DISCUSSION

The use of artificial lighting with LEDs was significant ($P \leq 0.05$) in the final mass of arugula Microgreens. The factors evaluated in FWS and DWS demonstrate that when using different luminosity spectra there is a significant variation in the evaluated parameters ($P \leq 0.05$) (Table 3).

TABLE 3.SUMMARY OF VARIANCE ANALYSIS RELATED TO THE EVALUATIONS: FRESH WEIGHT MASS (FWS), DRY WEIGHT OF SHOOT (DWS), AND *ARUGULA MICROGREENS* IN DIFFERENT ARTIFICIAL LIGHTING SPECTRA WITH LEDS.

SV	DF	Middle square	
		FWS	DWS
Treatment	5	1182,98**	24,846**
Blocks	4	11,95^{ns}	0,44^{ns}
Residue	20	73,68	1,49
CV (%)		19,89	21,17

SV.: source of variation; DF.: degree of freedom; C.V.: coefficient of variation. **: significant at the 1% probability level (p<0.01); ns: not significant (p≥0.05) by the F test.

In general, FWS was increased by the use of artificial lighting, regardless of the different spectra evaluated (Figure 2). The 3BQ treatment presented the best result, with a fresh mass of 55.54 g, resulting in plants up to 320.75% higher when compared to the control 13.2 g. Then, 1BQ+1BF+1FS, 3BF, and 3FS stand out, with masses of 53.56, 46.92, and 46.28 g, which demonstrate the superiority of 305.75, 255.45, and 250.61% of the control without the use of LEDs. In addition, the 2FS+1BF treatment, although it was lower than the other treatments, also showed superiority over the control, being 43.44 g of mass and 229.09% higher than the Control (Figure 2). [8],using complementary artificial lighting in hardwood, concluded that the blue, red, and white lights increased the agronomic characteristics of the crop significantly when compared to the control treatment.

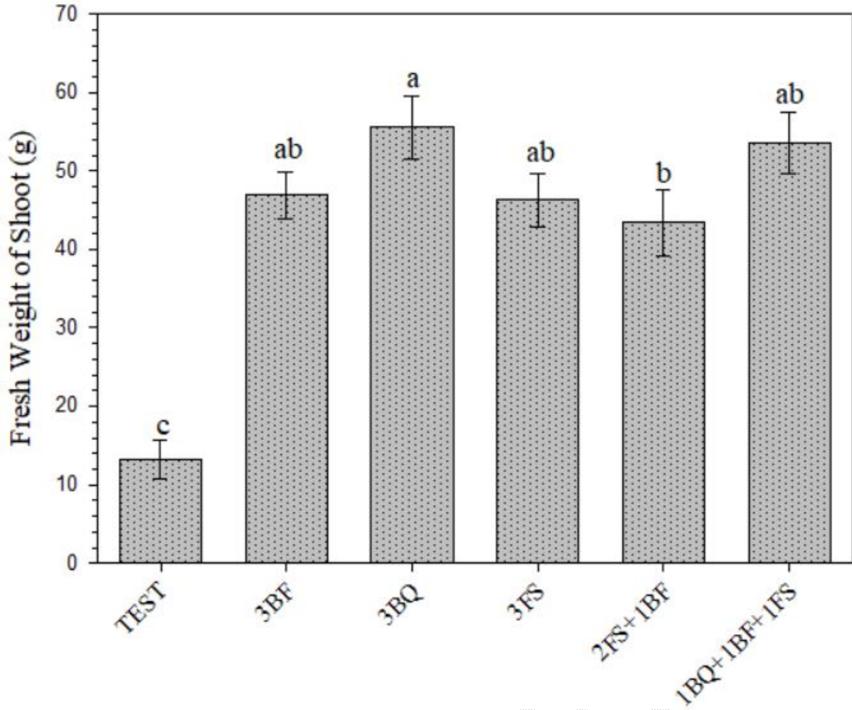

Figure 2. Fresh weight of shoot (FWS) of arugula Microgreens in different sources of artificial lighting with LEDs.

The MSPA characteristic is the main productivity parameter, in which there was a significant difference ($P \leq 0.05$), where treatments 1BQ+1BF+1FS, 3BF, and 3BQ obtained dry mass of 7.52, 7.26, and 6.94 g, with the control (1.62 g) being higher in 364.20, 348.15 and 328.39% respectively (Figure 3). Soon after, the 3FS treatment comes with 6.36 g, which makes it 292.59% higher than the control. Finally, the 3FS+1BF treatment with 4.98 g shows to be less effective than the others for this characteristic, but still with superiority of 207.41% over the control. The use of LEDs as light supplementation in commercial production may have influenced the increase in shoot dry mass thus improving productivity, due to the increase in the photosynthetic rate inside the canopy of the plant [9].

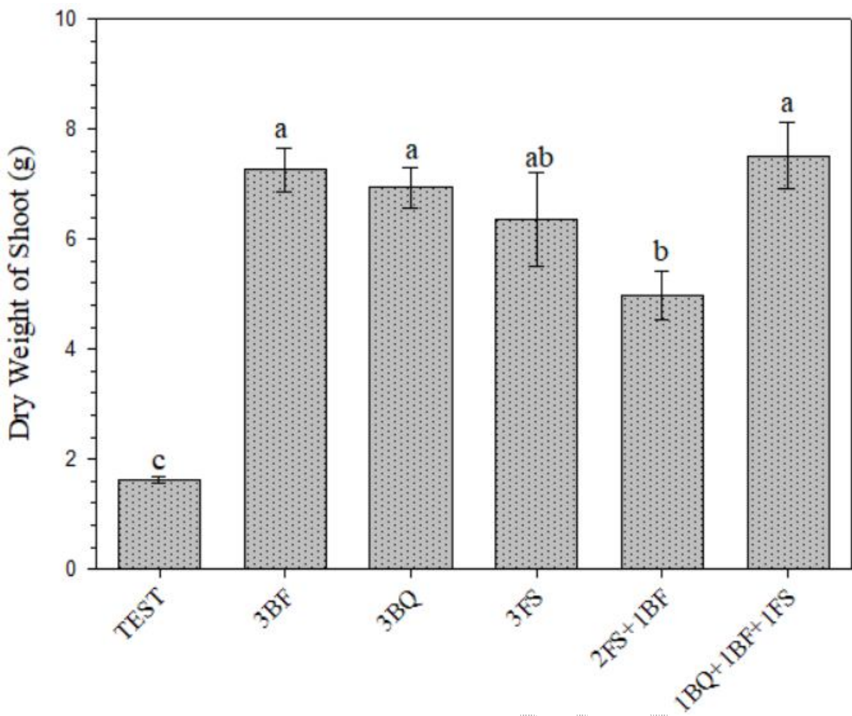

Figure 3. Dry weight of shoot (DWS) of arugula Microgreens in different sources of artificial lighting with LEDs.

It can be theorized through research conducted in the literature, that lighting with LEDs can achieve efficiency superior to natural lighting, since the light supply can be controlled to be uniform throughout the period or vary, according to the specific needs of the cultivation [10].

The fast production cycle, which can be elevated to maximum efficiency with advanced consumption techniques, makes this cultivation with the use of LED scans a profitable activity according to research conducted in the literature, especially when used in large centers, as they are crops of rapid return on investment [11].

CONCLUSION

The use of different artificial lighting spectra with LEDs increases the biomass production of *indoor* cultivation of arugula *microgreens*, which demonstrates greater efficiency in plant yield.

The highest yields of arugula microgreens were with the plates, 3 Super Power Led Cob 50w 220v Hot White 3000k - 3500k (3BQ), 3 Super Power Led Cob 50w 220v Cold White 6000k (3BF) and 1 Super Power Led Cob 50w 220v Full Spectrum Grow 380-840nm + 1 Super Power Led Cob 50w 220v Cold White 6000 + 1 Super Power Led Cob 50w 220v Warm White 3000k - 3500k (1FS+1BF+1BQ).

The lowest yield of arugula *microgreens*was observed with the use of the 2 Super Power Led Cob 50w 220v Full Spectrum Grow 380-840nm + 1 Super Power Led Cob 50w 220v Cold White 6000k (2FS+1BF).

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