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Studies on effect of light treatments on growth and flowering in arugula (*Eruca sativa*)

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Abstract

The increasing adoption of controlled environment agriculture has highlighted the importance of optimizing light quality and photoperiod for enhanced crop growth and productivity. The present study, entitled “Studies on the Effect of Light Treatments on Growth and Flowering in Arugula”, was conducted during 2025–2026 to evaluate the influence of different light spectra and durations on the growth performance of arugula (*Eruca sativa* L.). The experiment comprised two arugula varieties, UKES and UKES, exposed to combinations of red and blue light ratios (2R:1B and 2B:1R) under two photoperiods of 16 and 18 hours. Growth and flowering responses were assessed through observations on plant height, number of leaves, leaf length, leaf width, and root biomass. The results revealed significant variation among the treatments, indicating the critical role of light quality and duration in regulating plant development. Among the evaluated treatments, the 16-hour photoperiod combined with red and blue light spectra exhibited superior performance in promoting vegetative growth and biomass accumulation compared to the corresponding 18-hour treatments. Both varieties responded positively to optimized light conditions, although varietal differences were observed in the magnitude of response. The findings demonstrate that appropriate manipulation of light spectra and photoperiod can substantially improve growth and flowering characteristics of arugula under indoor cultivation systems. These results provide valuable insights for the development of efficient lighting strategies aimed at enhancing crop productivity in controlled environment agriculture.

Keywords: Arugula, Indoor cultivation, LED lighting, red light, blue light, photoperiod, controlled environment agriculture, growth parameters, flowering, biomass

Introduction

Arugula (*Eruca sativa*) is a leafy vegetable in the family Brassicaceae. It is an annual herbaceous plant distributed in the Mediterranean region. Arugula originated in the Mediterranean region and is known by its common names Rocket, True Rocket, Rocket Salad, Arugula, Roquette, or White Pepper (Gajra Garg and Vinay Sharma 2014) [3]. The name of this plant species is derived from the Latin word *Eruca*, which means a type of cabbage. The English The nutritional supply of arugula has been studied at different levels of qualitative and quantitative detail. In terms of macronutrients, ES leaves are a source of carbohydrate fibre, magnesium, calcium, and sodium, whereas the seeds are a source of fats, phosphorus, calcium, sodium, potassium, and magnesium. Arugula leaves are also rich in vitamins, including carotenes, tocopherols, vitamin C, and folic acid (Verhoeven *et al.*, 1996) [10]. In general, whole arugula is a source of vitamins A, C, and K, as well as thiamine, riboflavin, niacin, vitamin B-6 (pyridoxine), and pantothenic acid (Innocenti *et al.*, 2008) [5]. Arugula is commercially cultivated for its oil-bearing seeds and as a main crop under moisture-deficient and saline areas. It is not in great demand as an edible oil crop; hence, there is an obvious need to improve its oil quality so that it can find its place in the kitchen. Germplasm is the most valuable and essential raw material for crop improvement programs. Therefore, it is necessary to promote the use of this crop as a means to conserve its genetic diversity.

Indoor farms represent a group of integrated technologies that can be configured in different ways for producing different crops. These crop types include leafy vegetables, herbs, tomatoes, flowers and microgreens (Wong *et al.*, 2020) [11]. The structures used for production of the crops include greenhouses, high tunnels, buildings, or containers with artificial light sources (Choi *et*

al., 2015) [2]. Research on indoor production has focused on factors such as light quality, light intensity, and photoperiod. *Light* is very vital for indoor production because of its impact on plant growth and yield. *Light* affects plant growth rate including stem thickness, branching,

Materials and Methods

The present investigation entitled “Studies on the Effect of *Light* Treatments on Growth and Flowering in Arugula (*Eruca sativa* L.)” was conducted during the year 2025– 2026 at Urban Kisaan Private Limited, Gundlapochampally, Hyderabad, Telangana, India. The experiment was carried out under a controlled indoor cultivation system to evaluate the influence of different light spectra and photoperiods on the growth and flowering performance of arugula. Two arugula varieties, namely UKES and UKES, were subjected to varying combinations of red and blue LED light treatments under 16-hour and 18-hour photoperiods. The materials employed and the experimental procedures adopted for conducting the study are described in the following sections.



Fig 1: Overall Experimental Plot



Fig 2: Arugula Growth under LEDs

Table 1: Treatment details

Treatments	Cultivars	
UKES1	UKES2	
T ₁	Control	Control
T ₂	UKES1+2R:1B+18hr duration	UKES1+2R:1B+18hr duration
T ₃	UKES1+2R:1B+16hr duration	UKES1+2R:1B+16hr duration
T ₄	UKES1+2B:1R+18hr duration	UKES1+2B:1R+18hr duration
T ₅	UKES1+2B:1R+16hr duration	UKES1+2B:1R+16hr duration

Experimental Design

The experiment was conducted using a Factorial Completely Randomized Design (FCRD) comprising ten treatment combinations replicated three times. Each treatment unit consisted of 30 arugula plants cultivated in a Nutrient Film Technique (NFT) hydroponic system. The plants were arranged in an alternating pattern to ensure uniform spacing and plant population throughout the experimental units. Sowing and transplanting operations were carried out during the second week of August, and all agronomic and crop management practices were maintained uniformly across treatments to minimize experimental variation. For data collection, ten plants from each treatment within every replication were selected at random and permanently tagged. Observations recorded from these representative plants were used to calculate treatment means for subsequent statistical analysis.

Reasons for Adopting Factorial Completely Randomized Design (FCRD)

- Evaluation of Multiple Factors and Their Interactions.
- Suitability for Controlled Environmental Conditions.
- Improved Precision and Statistical Efficiency.

Results and Discussion

1. Plant height(cm)

Table 2: Effect of different organic manures on plant height(cm)

Treatments	15 days plant height	30 days plant height	45 days plant height							
UKE S1 (C1)	UKES 2 (C2)	Mean	UKE S1 (C1)	UKES 2 (C2)	Mean	UKE S1 (C1)	UKES 2 (C2)	Mean		
T ₁	Control	1.71	1.60	1.66	5.06	4.52	4.79	6.10	5.56	5.83
T ₂	2R:1B+18 hr duration	2.66	2.70	2.68	9.55	10.53	10.04	16.28	15.43	15.86
T ₃	2R:1B+16 hr duration	2.14	2.64	2.39	14.62	14.51	14.56	20.77	20.14	20.46
T ₄	2B:1R+18 hr duration	2.49	2.88	2.48	10.40	10.09	10.24	16.16	15.98	16.07
T ₅	2B:1R+16 hr duration	2.23	2.62	2.35	14.16	14.54	14.35	20.40	21.02	20.71
Mean	2.24	2.38		10.76	10.84		15.94	15.62		
	SEm±	CD (5%)	SEm±	CD (5%)	SEm±	CD (5%)				
Cultivars (C)	0.09	0.27	0.29	0.87	0.39	1.17				
Light treatments (L)	0.14	0.43	0.46	1.38	0.62	1.85				
CXL	0.20	0.61	0.65	1.95	0.88	2.61				

Plant height was significantly influenced by light treatments and cultivars at all stages of growth. At 15 DAS, the tallest plants were observed under the 2R:1B light combination with an 18-hour photoperiod, while the control recorded the lowest plant height. At 30 and 45 DAS, both 16-hour light treatments (2R:1B and 2B:1R) produced markedly taller plants than the 18-hour

treatments and control. The highest plant height at 45 DAS was recorded under the 2B:1R combination with a 16-hour photoperiod, closely followed by the 2R:1B treatment with a 16-hour photoperiod. Among the cultivars, UKES2 exhibited slightly greater plant height during the initial growth stages, whereas differences between

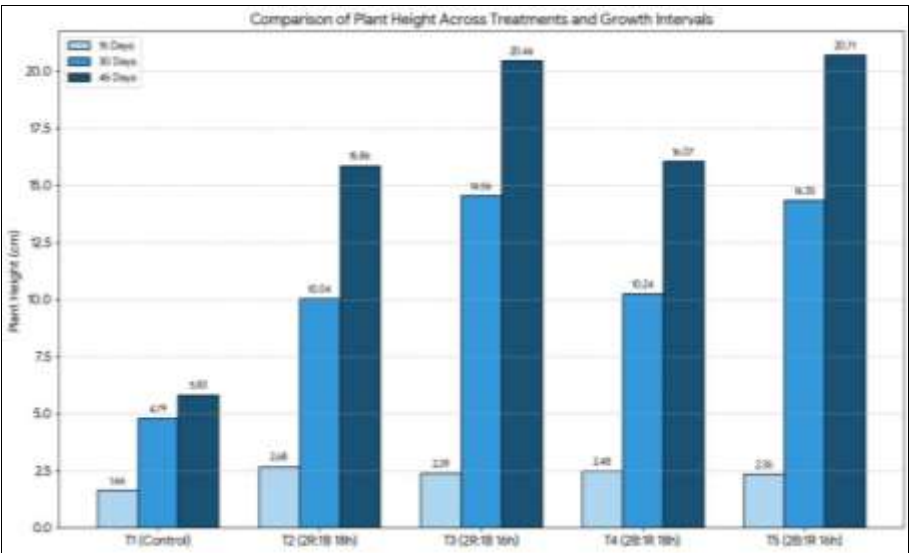


Fig 3: Graphical representation of plant height

2. Leaf length

Table 3: Effect of light treatments on leaf length

TREATMENTS	15 days after sowing	30 days after sowing	45 days after sowing							
UKES 1 (C1)	UKES 2 (C2)	Mean	UKES 1 (C1)	UKES 2 (C2)	Mean	UKES 1 (C1)	UKES 2 (C2)	Mean		
T ₁	Control	0.107	0.100	0.103	2.567	2.033	2.300	3.63	2.88	3.26
T ₂	2R:1B+18 hr duration	2.353	1.440	1.897	6.260	5.640	5.950	8.00	6.73	7.36
T ₃	2R:1B+16 hr duration	2.020	1.127	1.573	6.553	6.173	6.363	8.72	7.22	7.97
T ₄	2B:1R+18 hr duration	1.960	1.187	1.573	6.720	6.293	6.507	7.93	6.62	7.27
T ₅	2B:1R+16 hr duration	2.133	1.307	1.720	6.520	6.087	6.303	8.83	7.18	8.01
Mean	1.715	1.032		5.724	5.245		7.42	6.13		
	SEm±	CD(5%)	SEm±	CD(5%)	SEm±	CD(5%)				
Cultivars (C)	0.05	0.16	0.13	0.39	0.03	0.09				
Light treatments (L)	0.08	0.25	0.20	0.61	0.04	0.14				
CXL	0.12	0.36	0.29	0.87	0.06	0.20				

Leaf length was significantly affected by light treatments and cultivars throughout the crop growth period. The control treatment recorded the shortest leaves at all observation stages, whereas plants exposed to red and blue LED combinations exhibited enhanced leaf elongation. At 45 DAS, the maximum leaf length was observed under the 2B:1R light combination with a 16-hour photoperiod, closely followed by the 2R:1B combination with a 16-hour photoperiod. Among the cultivars, UKES consistently produced longer leaves than UKES. Overall, the results indicate that a 16-hour photoperiod was more effective than an 18-hour photoperiod in promoting leaf length under indoor cultivation conditions.

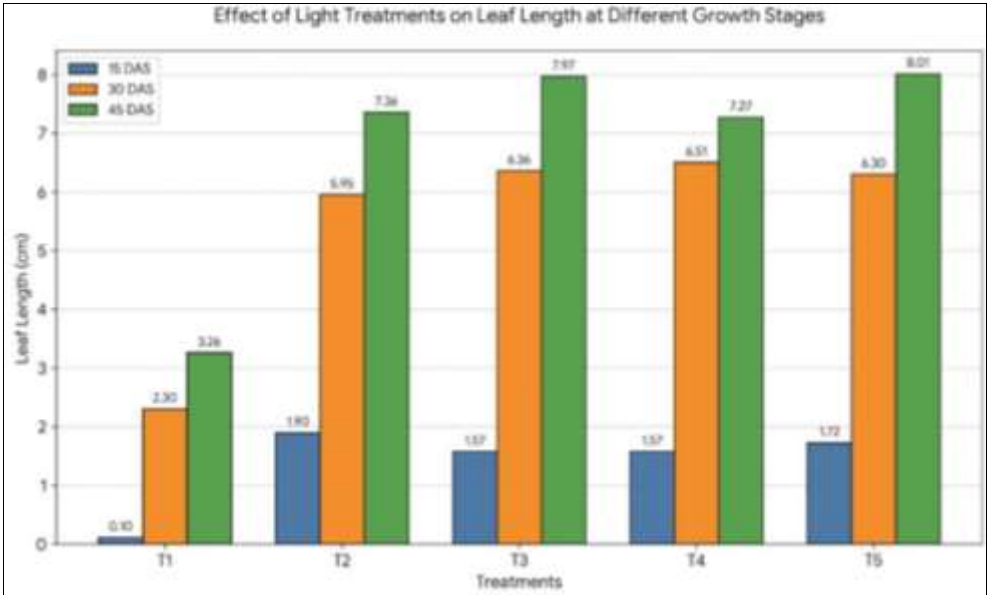


Fig 4: Graphical representation of leaf length

3. Leaf width

Leaf width was significantly influenced by both light treatments and cultivar differences throughout the experimental period. The control treatment consistently recorded the lowest leaf width at

15, 30, and 45 DAS, indicating limited leaf expansion under ambient conditions. In contrast, plants exposed to red and blue LED combinations exhibited substantially greater leaf width. At 45 DAS, the 2B:1R light

Table 4: Effect of light treatments on leaf width

TREATMENTS	15 days after sowing	30 days after sowing	45 days after sowing							
UKES 1 (C1)	UKES 2 (C2)	Mean	UKES 1 (C1)	UKES 2 (C2)	Mean	UKES 1 (C1)	UKES 2 (C2)	Mean		
T ₁	Control	0.19	0.20	0.19	1.00	1.00	1.00	1.50	1.50	1.50
T ₂	2R:1B+18 hr duration	1.49	1.01	1.25	4.02	3.36	3.69	4.60	4.28	4.44
T ₃	2R:1B+16 hr duration	1.68	0.76	1.22	4.80	3.26	4.03	5.33	4.34	4.83
T ₄	2B:1R+18 hr duration	1.53	0.86	1.19	4.09	3.20	3.64	4.82	4.13	4.47
T ₅	2B:1R+16 hr duration	1.58	0.90	1.24	4.79	3.32	4.06	5.42	4.28	4.85
Mean	1.29	0.74		3.74	2.82		4.33	3.70		
	SEm±	CD(5%)	SEm±	CD(5%)	SEm±	CD(5%)				
Cultivars (C)	0.04	0.12	0.03	0.10	0.03	0.09				
Light treatments (L)	0.06	0.19	0.05	0.16	0.04	0.14				
CXL	0.09	0.27	0.07	0.23	0.06	0.20				

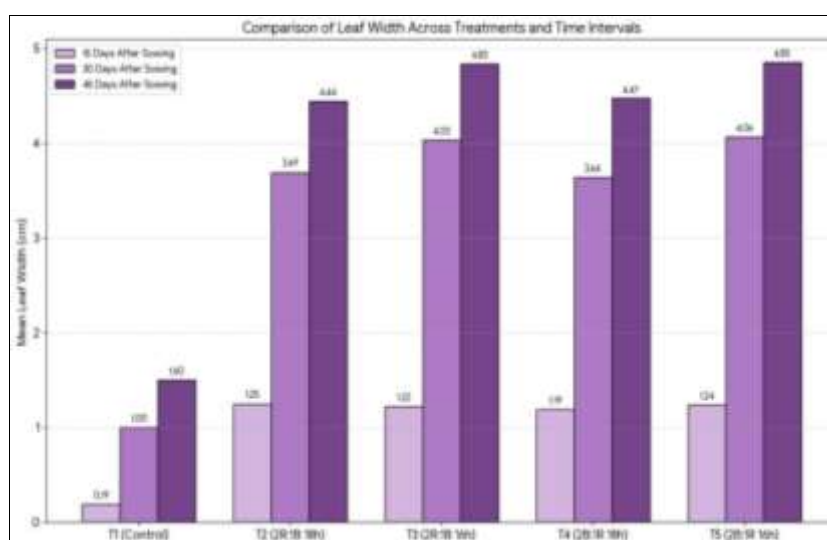


Fig 5: Graphical representation of leaf width

4. Number of leaves

Table 5: Effect of light treatments in leaf width

Treatments	15 days after sowing	30 days after sowing	45 days after sowing							
UKE S1 (C1)	UKES 2 (C2)	Mean	UKE S1 (C1)	UKES 2 (C2)	Mean	UKE S1 (C1)	UKES 2 (C2)	Mean		
T ₁	Control	2.26	2.13	2.20	4.00	5.26	4.16	4.13	3.93	4.03
T ₂	2R:1B+18 hr duration	4.00	3.80	3.90	5.80	5.80	5.80	11.06	11.66	11.36
T ₃	2R:1B+16 hr duration	3.93	3.93	3.93	6.26	5.86	6.06	14.20	13.06	13.63
T ₄	2B:1R+18 hr duration	3.93	3.80	3.86	6.00	5.93	5.96	11.60	12.80	12.20
T ₅	2B:1R+16 hr duration	3.60	3.86	3.73	6.00	5.93	5.96	13.53	13.53	13.53
Mean	3.54	3.50		5.61	5.57		10.90	11.00		
	SEm±	CD(5%)	SEm±	CD(5%)	SEm±	CD(5%)				
Cultivars (C)	0.03	0.11	0.11	0.35	0.34	1.03				
Light treatments (L)	0.06	0.18	0.18	0.55	0.55	1.64				
CXL	0.08	0.25	0.26	0.78	0.78	2.32				

The number of leaves was significantly affected by the different light treatments throughout the crop growth period. At all observation stages, plants grown under LED light combinations produced more leaves than those under the control treatment. At 15 and 30 DAS, the differences among the LED treatments were relatively small, but all outperformed the control. By 45 DAS, a marked increase in leaf production was observed under the 16-hour photoperiod treatments. The highest number of leaves was recorded under the 2R:1B light combination with a 16-hour

duration, closely followed by the 2B:1R treatment with the same photoperiod. Treatments receiving 18 hours of light also enhanced leaf production but were comparatively less effective. Cultivar differences were minimal, with both UKES and UKES exhibiting a similar response pattern across treatments. Overall, the results indicate that red and blue LED light combinations, particularly under a 16-hour photoperiod, promote greater leaf production and improve vegetative growth in arugula under indoor cultivation conditions.

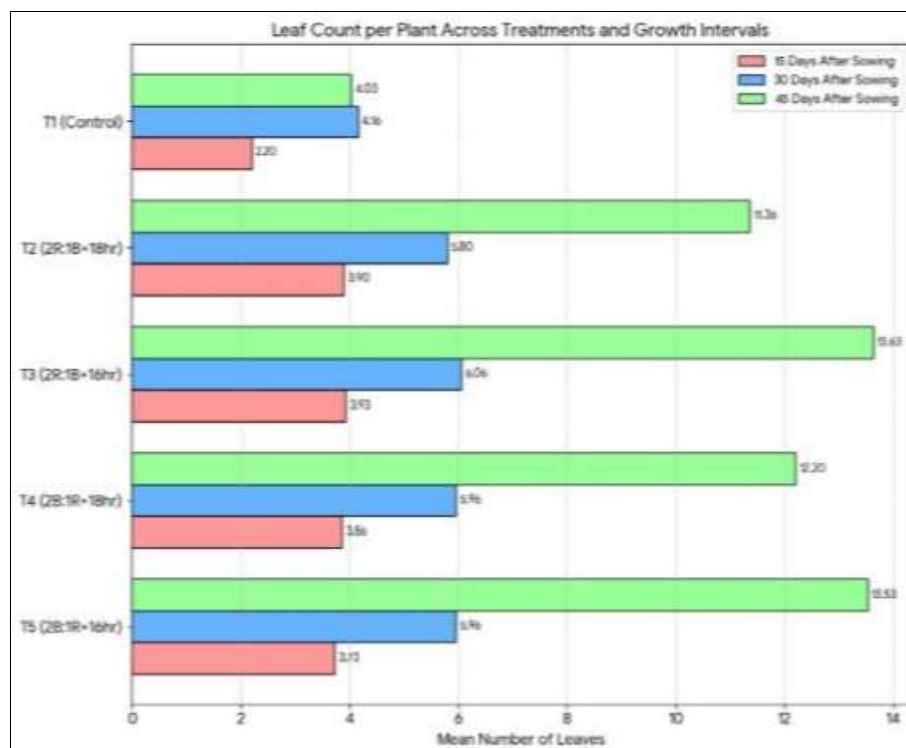


Fig 6: Graphical Representation of number of leaves

Conclusion

The present study demonstrated that both light quality and photoperiod significantly influenced the vegetative growth of arugula under indoor cultivation conditions. Among the evaluated treatments, the 16-hour photoperiod combined with red and blue LED spectra consistently promoted superior growth compared with the 18-hour photoperiod and control treatment. The

2B:1R light combination under a 16-hour duration exhibited the highest overall performance in terms of plant height, leaf length, and leaf width, while the 2R:1B combination with the same photoperiod produced the greatest number of leaves. The control treatment consistently recorded the lowest values for all growth parameters. Although minor varietal differences were observed, both UKES and UKES responded positively to optimized LED lighting conditions. Overall, the findings indicate that a 16-hour photoperiod with an appropriate red-to-blue light ratio is more effective for enhancing vegetative growth and improving crop performance in arugula cultivated under controlled indoor environments. These results provide useful guidance for the development of efficient lighting strategies in commercial indoor farming and controlled environment agriculture systems.

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