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Studies on effect of light spectrum and photoperiod interaction on acceleration flowering and performance on chilli (*Capsicum annum* L.) genotypes under indoor vertical systems

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Abstract

The present investigation entitled “Studies on Effect of Light Spectrum and Photoperiod Interaction on Acceleration of Flowering and Performance of Chilli (*Capsicum annum* L.)” was conducted to evaluate the influence of different LED light spectra and photoperiod combinations on the growth, flowering, and yield performance of chilli under indoor vertical farming conditions. Two chilli varieties, namely Thai chilli and Bullet chilli, were evaluated under five light treatments comprising different combinations of red and blue LED lights with varying photoperiods. Significant differences were observed among the treatments and varieties for vegetative growth, flowering behaviour, and yield attributes. Among the two varieties, Bullet chilli exhibited superior overall performance with better fruit number, fruit weight, and yield, indicating its suitability for controlled indoor cultivation systems. Among the light treatments, the combination of 1R:2B with 16 hours photoperiod showed better vegetative growth, while 2R:1B with 16 hours photoperiod promoted greater plant spread, leaf area, and earlier flowering compared to the control treatment. Overall, extended photoperiods combined with optimized red and blue light ratios enhanced plant growth and flowering under controlled conditions. The study demonstrated that manipulation of light quality and duration through LED technology can effectively improve growth, accelerate flowering, and enhance productivity of chilli, thereby showing promising potential for indoor vertical farming and speed-breeding applications.

Keywords: Chilli, *Capsicum annum*, LED light spectrum, photoperiod, indoor vertical farming, controlled environment agriculture, flowering acceleration, red and blue light, speed breeding, yield performance

1. Introduction

Chilli (*Capsicum annum* L.) belonging to the family Solanaceae with chromosome number $2n=2x=24$, is one of the most widely cultivated vegetable and spice crops across the world. It is primarily grown for its pungent green and ripe fruits, which are commonly used as vegetables, condiments, spices, and pickles. Chilli fruits are extensively utilized in culinary preparations to enhance flavour, colour, and pungency in food products. In addition to their culinary importance, chillies are considered a valuable source of vitamins A, C and E, along with several antioxidants and bioactive compounds beneficial for human health. Consumption of chilli is associated with various health-promoting effects such as improving immunity, supporting cardiovascular health, aiding metabolism, and assisting in weight management. The presence of capsaicin in chilli contributes to its medicinal properties and has been widely used in pharmaceutical formulations and therapeutic preparations for ailments such as cold, sore throat, asthma, chest congestion, headaches, and arthritis.

In addition to its nutritional and medicinal importance, chilli holds a prominent position in the agricultural economy and food processing industry. The crop is widely utilized in different forms such as fresh fruits, dried pods, powders, sauces, and other processed products to improve the flavour, colour, and pungency of food preparations. Chilli cultivation plays a vital role in

generating employment opportunities and serves as a significant source of income for farmers in several countries, particularly in India. Owing to its adaptability to varied climatic conditions, high consumer demand, and considerable export value, chilli is recognized as one of the most economically important spice crops cultivated across the world.

Chilli is one of the most widely cultivated spice crops in the world, with a global production of nearly 7 million tonnes grown over an area of approximately 1.5 million hectares. India occupies a leading position in chilli production, followed by countries such as China and Pakistan, indicating the major contribution of Asian nations to global chilli cultivation. Although chilli is produced across many parts of the world, the highest consumption and demand are observed in countries including India, China, Mexico, Thailand, the United States, the United Kingdom, Germany, and Sweden. Among the cultivated species, *Capsicum annuum* is the most widely grown and commercially important species, while certain pungent types belong to *Capsicum frutescens*. Chilli is extensively used as a spice in various cuisines to impart characteristic pungency, flavour, and colour to food preparations and sauces. The pungent nature of chilli is mainly attributed to the presence of capsaicin and other related compounds collectively known as capsaicinoids.

Research related to indoor crop production has primarily emphasized the role of environmental factors such as light quality, light intensity, and photoperiod in regulating plant growth and productivity. Among these factors, light plays a crucial role in controlled environment agriculture due to its direct influence on photosynthesis and plant developmental processes. Variations in light conditions can significantly affect plant growth characteristics including stem thickness, branching pattern, rooting behaviour, seed germination, and flowering responses. Recent studies have demonstrated that the use of supplemental lighting with different spectral compositions, such as UV-A, blue, green, red, far-red, and white LED lights, can markedly influence the accumulation of phytochemical compounds including anthocyanins, carotenoids, chlorophylls, and flavonoids in leafy vegetables like lettuce. The synthesis of carotenoids in fruits and vegetables is strongly influenced by both light intensity and spectral quality. Furthermore, in greenhouse cultivation systems, the limited availability of UV-B radiation may alter flavonoid concentration in leafy crops, thereby affecting their flavour, nutritional quality, and visual appearance.

2. Materials and Methods

The present investigation entitled “*Studies on effect of light spectrum and photoperiod interaction on accelerated flowering and performance on chilli genotypes (Capsicum annum L.) under indoor vertical systems*” 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 spectrum and photoperiods on the growth and flowering performance of arugula. Two arugula varieties, namely Thai chilli and Bullet chilli were subjected to varying combinations of red and blue LED light treatments under 14-hour and 16-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	
	Thai chilli	Bullet chilli
T ₁	1R:2B+14 hr duration	1R:2B+14 hr duration
T ₂	1R:2B+16 hr duration	1R:2B+16 hr duration
T ₃	2R:1B+14 hr duration	2R:1B+14 hr duration
T ₄	2R:1B+16 hr duration	2R:1B+16 hr duration
T ₅	Control	Control

2.1 Experimental Design

The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with ten treatments and 3 replications. Each treatment consisted of 30 plants established in pots arranged across vertical layers. One plant pot were randomly selected and tagged for recording observations. Planting was carried out during the last week of August 2025. Throughout the study period, uniform cultural practices were followed across all treatments. In each treatment, ten uniformly healthy plants were randomly selected for recording observations in each replication. The mean value for each parameter was calculated based on data recorded from selected plants

3. Results and Discussion

3.1 Plant height(cm)

Table 2: Effect of different light spectrum on plant height(cm)

Treatments		30 days plant height			60 days plant height		
		Thai chilli (C1)	Bullet chilli (C2)	Mean	Thai chilli (C1)	Bullet chilli (C2)	Mean
T ₁	1R:2B+14 Hours of light	10.322	11.389	10.856	22.100	20.822	21.461
T ₂	1R:2B+16 Hours of light	11.278	11.478	11.378	22.622	21.022	21.822
T ₃	2R:1B+14 Hours of light	11.567	10.622	11.094	18.111	16.711	17.411
T ₄	2R:1B+16 Hours of light	11.411	11.056	11.233	18.689	16.544	17.617
T ₅	Control (White light)	7.589	7.389	7.489	13.278	13.678	13.478
Mean		10.433	10.387		18.960	17.756	
		SEm±		CD (5%)	SEm±		CD (5%)
Cultivars (C)		0.303		0.900	0.166		0.495
Light treatments (L)		0.479		1.423	0.263		0.782
CXL		0.677		2.012	0.372		1.106

Plant height of chilli was significantly influenced by both light spectrum and photoperiod under indoor growing conditions. Among the different light treatments, the combination of a higher proportion of blue light with an extended photoperiod (1R:2B + 16 hours of light) resulted in the greatest plant height at both observation stages, indicating its effectiveness in promoting vegetative growth. Treatments receiving a higher

proportion of red light produced comparatively lower plant height, while the control treatment recorded the least growth. Among the two varieties, Thai chilli exhibited slightly greater plant height than Bullet chilli. Overall, the results suggest that a higher blue light proportion combined with a longer photoperiod is most effective for enhancing plant height in chilli under controlled environment conditions.

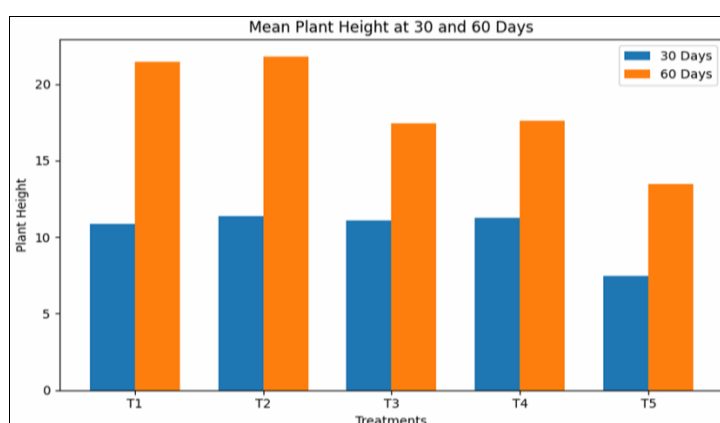


Fig 3: Graphical representation of plant height

3.2 Plant spread

Table 3: Effect of light treatments on Plant spread

Treatments		30 days plant spread			60 days plant spread		
		Thai chilli (C1)	Bullet chilli (C2)	Mean	Thai chilli (C1)	Bullet chilli (C2)	Mean
T ₁	1R:2B+14 Hours of light	12.489	12.900	12.694	16.544	15.500	16.022
T ₂	1R:2B+16 Hours of light	12.878	14.144	13.511	16.756	18.033	17.394
T ₃	2R:1B+14 Hours of light	14.889	15.600	15.244	19.778	20.311	20.044
T ₄	2R:1B+16 Hours of light	15.856	16.122	15.989	20.511	19.900	20.206
T ₅	Control (White light)	11.411	11.700	11.556	13.867	13.933	13.900
Mean		13.504	14.093		17.491	17.536	
		SEm±		CD (5%)	SEm±		CD (5%)
Cultivars (C)		0.256		0.761	0.166		0.714
Light treatments (L)		0.405		1.204	0.263		1.130
CXL		0.573		1.703	0.372		1.597

Plant spread was significantly affected by the interaction of light spectrum and photoperiod in chilli grown under indoor conditions. Treatments with a higher proportion of red light promoted greater canopy expansion compared to treatments with a higher proportion of blue light and the control. Among all treatments, the combination of 2R:1B with a longer photoperiod produced the maximum plant spread, indicating that red-enriched light coupled with extended light exposure enhances

lateral growth and branching. The control treatment recorded the lowest plant spread throughout the growth period. Between the two varieties, Bullet chilli showed a slightly wider plant spread than Thai chilli. Overall, the results indicate that a red-dominant light spectrum combined with a longer photoperiod is most effective for improving plant spread in chilli under controlled environment cultivation.

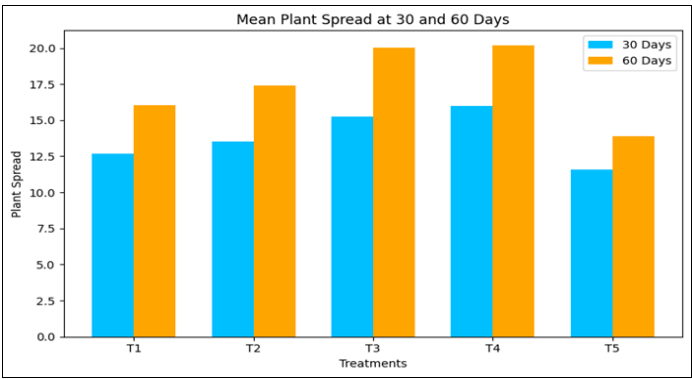


Fig 4: Graphical representation of Plant spread

3.3 Leaf area

Leaf area of chilli was significantly influenced by the interaction of light spectrum and photoperiod under indoor growing conditions. Treatments with a higher proportion of red light generally promoted greater leaf expansion compared to blue-light-dominant treatments and the control. Among all treatments, the combination of 2R:1B with a shorter photoperiod recorded the highest leaf area, indicating its effectiveness in enhancing

leaf development and canopy growth. The control treatment exhibited comparatively lower leaf area, suggesting that optimized red and blue light combinations are more beneficial than white light alone. Between the two varieties, Bullet chilli produced a slightly larger leaf area than Thai chilli. Overall, the results indicate that a red-dominant light spectrum is more effective in promoting leaf area development in chilli under controlled environment conditions.

Table 4: Effect of light treatments on leaf area

Treatments		30 days Leaf area			60 days Leaf area		
		Thai chilli (C1)	Bullet chilli (C2)	Mean	Thai chilli (C1)	Bullet chilli (C2)	Mean
T ₁	1R:2B+14 Hours of light	1.322	1.395	1.358	14.238	12.272	13.255
T ₂	1R:2B+16 Hours of light	2.220	1.249	1.735	14.478	11.467	12.972
T ₃	2R:1B+14 Hours of light	1.642	1.225	1.433	13.821	20.570	17.196
T ₄	2R:1B+16 Hours of light	1.450	0.884	1.167	15.970	17.227	16.599
T ₅	Control (White light)	0.906	1.491	1.198	11.214	12.670	11.942
Mean		1.508	1.249		13.944	14.841	
		SEm±		CD (5%)	SEm±		CD (5%)
Cultivars (C)		0.141		0.574	0.456		1.355
Light treatments (L)		0.223		0.908	0.721		2.143
CXL		0.316		1.284	1.020		3.030

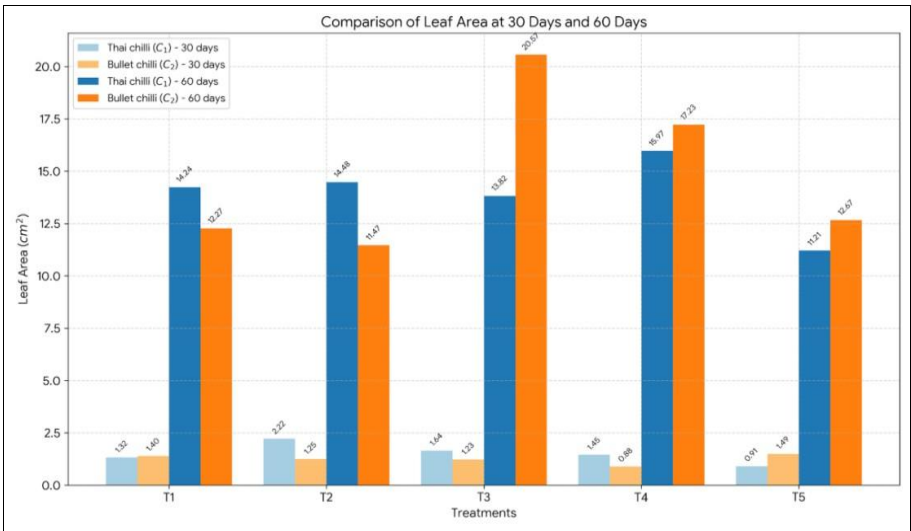


Fig 5: Graphical representation of leaf area

3.4 Number of days to flower intiation

The analysis of variance indicated that the treatments exerted a highly significant influence on the studied parameter, as evidenced by the significant F-value (36.634) at 1 per cent level of significance. Among the different treatments, Treatment 5 and Treatment 10 recorded the highest mean value (149.111), demonstrating their superiority over the remaining treatments.

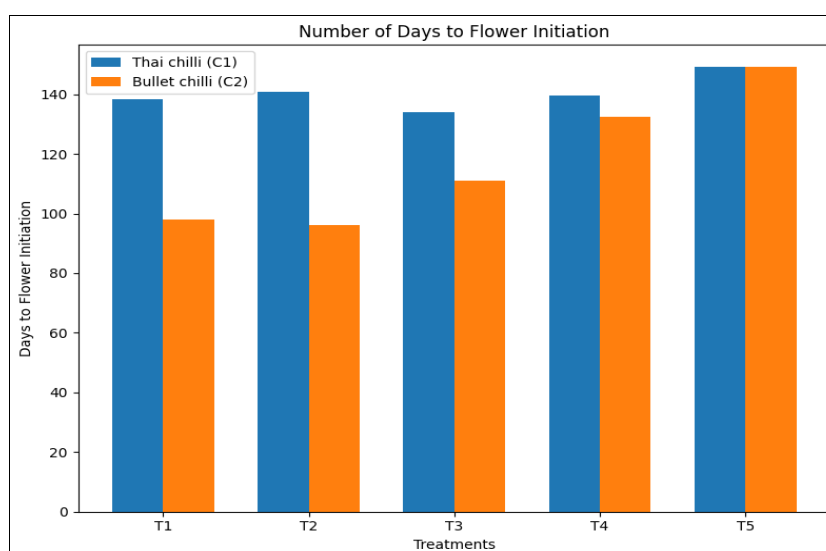
These were followed by Treatment 2 (140.889), Treatment 4 (139.667), Treatment 1 (138.333), Treatment 3 (133.889), and Treatment 9 (132.444). In contrast, the lowest mean values were observed in Treatment 7 (96.000) and Treatment 6 (98.111), while Treatment 8 recorded a comparatively moderate value (111.000). The critical difference values for treatments were 9.755 at 5 percent and 13.363 at 1 per cent level, indicating that

the differences among the superior and inferior treatments were statistically significant. Treatments 5 and 10 were found to be statistically at par with each other since both recorded identical mean values. Similarly, Treatments 1, 2, and 4 showed close resemblance with marginal variation among them. The

comparatively low coefficient of variation (4.413%) indicated good precision and reliability of the experimental results, thereby confirming the consistency of the observed treatment effects.

Table 5: Effect of light treatments on no of days to flower initiation

Treatments		No of days to flower initiation		
		Thai chilli (C1)	Bullet chilli (C2)	Mean
T ₁	1R:2B+14 Hours of light	138.333	98.111	118.222
T ₂	1R:2B+16 Hours of light	140.889	96.000	118.444
T ₃	2R:1B+14 Hours of light	133.889	111.000	122.444
T ₄	2R:1B+16 Hours of light	139.667	132.444	136.056
T ₅	Control (White light)	149.111	149.111	149.111
Mean		140.378	117.333	
		SEm±		CD (5%)
Cultivars (C)		1.469		4.363
Light treatments (L)		2.321		6.898
CXL		3.283		9.755



Conclusion

Among the two chilli varieties evaluated, Bullet chilli exhibited superior overall performance, particularly with respect to reproductive and yield attributes. It recorded higher fruit number, fruit weight, and yield per plant compared to Thai chilli, indicating its better adaptability and productivity under controlled indoor growing conditions. Therefore, Bullet chilli can be considered the more suitable genotype for indoor vertical farming and speed-breeding applications. Regarding light treatments, the 1R:2B LED spectrum with a 14-hour photoperiod emerged as the most effective treatment for enhancing yield and fruit production, while the 1R:2B LED spectrum with a 16-hour photoperiod promoted maximum vegetative growth and chlorophyll accumulation. The findings demonstrate that blue-enriched LED lighting plays a critical role in improving plant growth, productivity, and quality traits of chilli under controlled environments. Hence, the combination of blue-dominant LED light and optimized photoperiod can be recommended for efficient indoor cultivation of chilli.

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