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Effect of Different Types of Lights on Growth, Yield and Quality of Kale (*Brassica oleracea var. Acephala*)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A research project was conducted to investigate the impact of different types of lighting on the growth, yield, and quality of Kale (*Brassica oleracea var Acephala)*, under the Prayagraj Agro Climatic conditions. The experiment comprised of treatments T_0 (Outdoor under sunlight), T_1 (LED bulb white), T_2 (LED tube white), T_3 (General bulb), T_4 (LED bulb full spectrum), T_5 (LED white bulb + LED bulb full spectrum), T_6 (LED tube white + LED bulb full spectrum), T_7 (General bulb + LED bulb full spectrum), T_8 (LED bulb full spectrum). To the study's findings, among the various treatment levels, treatment T_2(LED tube white) showed the highest values in growth parameters such as plant height (30.01 cm), petiole length (15.07 cm), and number of leaves per plant (14.33 leaves). It also demonstrated the highest yield parameters, fresh weight of leaves (24.40 gms), leaves yield/bag (50.54 g). Additionally, T_2 exhibited better quality parameters such as total soluble solids (3.23 °Brix), shelf-life (4.67 days), and chlorophyll content (56.40 nmol cm^2), while the lowest values were observed in T_4 (LED Full spectrum).

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Keywords: Kale plant growth; LED; leaf yield; chlorophyll content.

1. INTRODUCTION

Kale, scientifically known as *Brassica oleracea*, has a long history of cultivation that spans over two millennia. Its resistance to frost has made it especially important in colder regions throughout history. As a member of the Brassicaceae family, kale is considered one of the most important leafy green vegetables. The word "kale" is derived from the Scottish term "coles" or "caulis," which the Greeks and Romans used to refer to cabbage-like plants. The edible portions of kale are highly curled, bluish-green leaves, and the plant does not form a solid head. Kale is one of the oldest forms of cabbage and originally comes from the eastern Mediterranean region of Europe. It has a similar appearance to the leafy canola plant. In the 19th century, kale was introduced as a minor temperate vegetable in India. Although it is rarely found in India, it is commercially grown on a large scale in Kashmir and to a limited extent in Jammu, Assam, and Himachal Pradesh. Kale is a food that is low in calories and has a significant number of vitamins, particularly vitamin C, E, and K, as well as micronutrients such as iron, zinc, and manganese, and macronutrients like calcium and magnesium. It is also a source of dietary fibre, glutamine (an amino acid with anti-inflammatory properties), and plant phytochemicals including polyphenols, flavonoids, and carotenes [1]. Consuming leafy vegetables on a daily basis can reduce the risk of cancer and heart disease, prevent fatigue, promote overall well-being, and delay the effects of aging. The use of various colours of light to demonstrate the relationship between light and plant growth is limited to three distinct colours: red, blue, and yellow. Photosynthesis is the food-making process in green parts of plants that is powered by light. Green is the colour most leaves reflect rather than absorbing, which is why leaves appear green. A promising technological advancement to obtain high density growth and manipulate morphological traits and phytochemical composition of crops is the use of multilayer production under sole-source (SS) light-emitting diodes (LEDs) as an artificial lighting system in vertical farming operations. Light plays a crucial role in plant growth and morphology, and the recent LED technology has several advantages such as energy efficiency, low maintenance cost, longevity, and the possibility to control spectral composition and select high light intensity while maintaining low heat emission. Optimal management of light intensity and spectral composition is required to achieve optimal yield, appearance, and nutritional quality of plants. Green light can deeply penetrate plant canopies and affect plant growth and the synthesis of bioactive compounds. The effects of green light on plant physiology depend on its proportion in combination with red and blue LED lighting in controlled environmental agriculture. High proportions of green light (25-44%) can reverse the effects of blue or red light, leading to stem growth rate inhibition, reduced chloroplast gene expression, reduced stomatal opening, and decreased phytochemical accumulation. This can negatively affect the quality of green leafy vegetables.

2. MATERIALS AND METHODS

The present investigation entitled was done to understand the plant growth, fruit yield and quality of Kale crop variety curly leaf under influence of different lights. The details of the materials used, and the methods adopted in the investigation, which was carried out at Horticultural Research Farm (HRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *winter* season of 2022 are described under the following heads. The 8 different lights which were used and mentioned in Table 1 and replicated thrice. Observations were recorded at different stages of growth periods *viz.* Plant height (15, 30, 60 DAS); length of petiole, number of leaves per plant, days to leaves picking, fresh weight of leaves, leaf yield/bag, TSS, shelf life and chlorophyll content. The data were statistically analysed by the method suggested by Fisher and Yates, [2].

Table 1. Light treatments

Treatment notation	Photosynthetically active radiation (PAR)
T_0	Outdoor under sunlight
T_1	LED bulb white
T_2	LED tube white
T_3	General bulb
T_4	LED bulb full spectrum
T_5	LED white bulb + LED bulb full spectrum
T_6	LED tube white + LED bulb full spectrum
T_7	General bulb + LED bulb full spectrum
T_8	LED bulb full spectrum

3. RESULTS AND DISCUSSION

3.1 Plant Height

The data pertaining to effect of application on height of plant is presented in Table 2. At 15 DAS treatment T_2 produced tallest plant of height (7.87) cm followed by treatment T_0 (7.43), treatment T_1 (7.33), treatment T_6 (7.07), and treatment T_4 significantly recorded the lowest height of plant (6.01). At 30 DAS treatment T_2 produced tallest plant of height (18.03 cm) followed by treatment T_0 (18.03), treatment T_1(17.29) treatment T_6 (17.17), treatment T_5 (16.93), T_4 significantly recorded the lowest height of plant (15.67 cm). At 60 DAS treatment T_2 produced tallest plant height (30.10cm) followed by treatment T_0 (27.78cm), treatment T_1 (27.00cm), treatment T_6 (26.76cm), treatment T_8 (25.03cm), and treatment T_4 significantly recorded the lowest height of plant (22.75cm). Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale.

3.2 Length of Petiole (cm)

The data pertaining to effect of application on Length of petiole is presented in Table 2. Treatment T_2 produced largest petiole (15.07 cm) followed by treatment T_0 (13.92cm), treatment T_3 (13.24), treatment T_6 (12.60cm), and treatment T_4 recorded significantly the lowest main branch (9.45cm). Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale.

3.3 Number of Leaves/Plants

The data pertaining to effect of application on Number of leaves/plants is presented in Table 2. Treatment T_2 produced highest Number of leaves/plant (14.33 leaves) followed by treatment T_0 (13.67 leaves), T_1 (13.00 leaves), treatment T_3 (12.67 leaves), treatment T_6 (12.33 leaves), and treatment T_4 significantly recorded the lowest Number of leaves/plant (11.00 leaves). Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale.

3.4 Days to Leaves Picking

Treatment T_2 produced higher Days of leaves picking 62.67 followed by treatment T_0 (66.67), treatment T_1 (68.67) treatment T_3 (69.00), treatment T_6 (69.33), T_4 significantly recorded the lower Days of leaves picking 75.00. Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale.

3.5 Fresh Weight of Leaves

Treatment T_2 produced highest Fresh weight of leaves 24.40 g followed by treatment T_0 (22.29 g), treatment T_1 (21.48 g), treatment T_3 (20.83 g), treatment T_6 (20.51 g), T_4 recorded significantly the lowest Fresh weight of leaves 14.48 g. Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale.

3.6 Leaf Yield/Bag(g)

Treatment T_2 produced highest Leaf yield/bag 50.54g followed by treatment T_0 (45.57g), treatment T_1 (43.92g), treatment T_3 (42.96g), treatment T_6 (42.67g), T_4 significantly recorded the lowest Leaf yield/bag 23.22g. Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale.

3.7 Leaves Yield/Hectare (Kg/ha)

Estimated leaves yield per hectare was observed in Treatment T_2 produced High Leaves yield/hectare 14.93 followed by treatment T_0 (14.91), treatment T_1 (14.38), treatment T_3 (14.30), treatment T_6 (13.80), T_4 significantly recorded the lowest Leaves yield/hectare10.49. Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. (2020) in rapeseeds; Zhang et al. [6] in Kale [7-9].

3.8 TSS

Treatment T_2 produced high TSS 3.23 °Brix followed by treatment T_0 (2.19 °Brix), treatment T_1 (1.72 °Brix), treatment T_7 (1.58 °Brix), treatment T_6 (1.53 °Brix), T_4 recorded significantly the lowest TSS 0.51 °Brix. Similar findings were reported by Gerovac et al. [3] and Ying et al. [4] in Brassicas; Yao et al. [5] and Yao et al. in rapeseeds; Zhang et al. [6] in Kale.

Table 2. Effect of different types of lights on growth, yield and quality of Kale

Treatment Notation	Photosynthetically Active Radiation (PAR)	Plant height (cm) 15DAS	Plant height (cm) 30 DAS	Plant height (cm) 60 DAS	Length of petiole (cm)	Number of leaves/ plants	Days to leaves picking	Fresh weight of leaves (g)	Leaves yield/ bag (g)	Yield per hectare (Kg/ha)	TSS [°Brix]	Shelf-life (days)	Chlorophyll content (nmol cm^2)
T_0	Outdoor under sunlight	7.43	18.13	27.78	13.92	12.00	66.67	22.29	45.57	14.91	2.91	4	52.54
T_1	LED bulb white	7.33	17.29	27	13.29	11.33	68.67	21.48	43.92	14.38	1.72	3.67	50.17
T_2	LED tube white	7.87	18.03	30.01	15.07	14.33	62.67	24.4	50.54	14.93	3.23	4.67	56.4
T_3	General bulb	6.48	16.01	23.08	13.24	12.33	69.00	20.83	42.96	14.30	1.37	2.67	44.39
T_4	LED bulb full spectrum	6.01	15.67	22.75	9.45	12.33	75.00	15.78	23.22	10.49	0.51	1.67	40.41
T_5	LED white bulb + LED bulb full spectrum	6.87	16.93	23.91	11.47	11.00	71.00	16.15	33.89	11.13	1.22	2.67	42.39
T_6	LED tube white + LED bulb full spectrum	7.07	17.18	26.76	12.6	13.67	69.33	20.51	42.67	13.80	1.53	3.33	48.23
T_7	General bulb + LED bulb full spectrum	6.81	17.78	23.13	10.92	12.67	72.67	14.48	33.63	11.45	1.58	3.33	49.62
T_8	LED bulb full spectrum	6.67	16.43	25.03	12.35	13.00	69.67	17.98	39.45	12.52	1.39	2.67	45.74
'F' Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E. (m) (±)		**0.697**	**0.079**	**0.103**	**0.213**	**1.150**	**1.455**	**0.023**	**0.083**	**1.000**	**0.261**	**0.803**	**0.075**
C.D. (5%)		**0.144**	**0.168**	**0.219**	**0.455**	**1.310**	**3.111**	**0.049**	**0.178**	**2.138**	**0.557**	**1.126**	**0.035**
C.V.		**12.293**	**0.573**	**0.493**	**0.491**	**11.250**	**2.568**	**0.146**	**0.0258**	**9.346**	**19.511**	**13.212**	**0.123**

3.9 Shelf-life

Treatment T_2 produced high Shelf life 4.67 days followed by treatment T_0 (4.00 days), treatment T_1 (3.67 days), treatment T_7 (3.33 days), treatment T_6 (3.33 days), T_4 significantly recorded the lowest Shelf life 1.67 days.

3.10 Chlorophyll Content

Treatment T_2 produced high Chlorophyll content 56.40 nmol cm^2 followed by treatment T_0 (52.54 nmol cm^2), treatment T_1 (50.17 nmol cm^2), treatment T_7 (49.62 nmol cm^2), treatment T_6 (48.23 nmol cm^2), T_8 significantly recorded the lowest Chlorophyll content 40.39 nmol cm^2.

4. CONCLUSION

Based on the findings of present investigation, it is concluded that treatment T_2 (LED Tube White) performed best in respect to all other treatments for growth yield and quality of Kale under influence of lights.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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