

Original Research Article

Effect of different types of light on growth, yield and quality of Kale” (*Brassica oleracea* var. *Acephala*)

ABSTRACT

A research project was conducted to investigate the impact of different types of light on the growth, yield, and quality of Kale (*Brassica oleracea* var. *Acephala*), under the Prayagraj Agro Climatic conditions. The study was conducted at the Vegetable Research Farm of Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, Uttar Pradesh (India), during the academic year of 2020-2022. The experiment utilized a statistical design of Randomized Block Design with two replications. According to the study's findings, among the 8 light treatments, treatment T₂ (LED tube white) showed the highest values in growth parameters such as plant height (30.01cm), petiole length (15.07cm), and number of leaves per plant (14.33 leaves). It also demonstrated the highest yield parameters, fresh weight of leaves (24.40gms), leaves yield per bag (50.54 g). Additionally, T₂ exhibited better quality parameters such as total soluble solids (3.23 °Brix), shelf-life (4.67 days), and chlorophyll content (56.40 nmol cm²), while the lowest values were observed in T₄ (LED FULL SPECTRUM).

Keywords: Kale plant growth, yield and quality.

Comment [OP1]: The full name of the institution and location of the experiments should be presented at 'methods' section

Comment [OP2]: The 8 light treatments must be included in the abstract, as well as the observed plant descriptors

Comment [OP3]: T₄ had the lowest results at all the observed descriptors, except for chlorophyll content

Comment [OP4]: What is the size of the bag? What is the material (plastic, tissue?)

Comment [OP5]: Keywords must be reviewed, it repeats the title LED, leaf yield, chlorophyll content Etc.

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 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. 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 leaves that is powered by light. Green is the colour that 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.

Comment [OP6]: Bibliographic reference must be included to support the sentence

Comment [OP7]: Not only leaves, also in green herbaceous stems and fruits

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.

MATERIAL AND METHODS

The investigation 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. The details

of the 8 different light used are mentioned in table 1 and replicated thrice. Observations were recorded at the different stages of growth periods. The data were statistically analysed by the method suggested by Fisher and Yates, 1936.

Table 1 Light Treatments Details

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

Comment [OP9]: The observed descriptors must be listed here, as well as the precise methodology of sampling

Comment [OP10]: You should include a resume of the used statistical analysis, as well as the reference to the informatics program that was used

Comment [OP11]: Not detailed at all! What wave length/intensity of the light, technical characteristics,
The table is enormous and contains little information, you can transform it in text or prepare a table with 4 columns to save space

RESULTS AND DISCUSSION

Plant height

The data pertaining to effect of application on height of plant is presented in Table.2. At 15 DAS treatment T₂ produced tallest plant of height (7.87) cm followed by treatment T₀ (7.43), treatment T₁ (7.33), treatment T₆(7.07), and treatment T₄ significantly recorded the lowest height of plant (6.01).At 30 DAS treatment T₂ produced tallest plant of height (18.03 cm) followed by treatment T₀ (18.03), treatment T₁(17.29) treatment T₆ (17.17), treatment T₅(16.93), T₄ significantly recorded the lowest height of plant (15.67 cm).At 60 DAS treatment T₂ produced tallest plant height (30.10cm) followed by treatment T₀(27.78cm), treatment T₁ (27.00cm), treatment T₆ (26.76cm), treatment T₈ (25.03cm), and treatment T₄ significantly recorded the lowest height of plant (22.75cm).Similar findings were reported by Gerovacet *et al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Length of petiole (cm)

The data pertaining to effect of application on Length of petiole is presented in Table.2. Treatment T₂ produced largest petiole (15.07 cm) followed by treatment T₀(13.92cm), treatment T₃ (13.24), treatment T₆ (12.60cm), and treatment T₄ recorded significantly the lowest main branch (9.45cm).Similar findings were reported by Gerovacet *et al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Number of leaves/plants

The data pertaining to effect of application on Number of leaves/plants is presented in Table.2. Treatment T₂ produced highest Number of leaves/plant (14.33 leaves) followed by treatment T₀(13.67 leaves), T₁ (13.00 leaves), treatment T₃(12.67 leaves), treatment T₆(12.33 leaves), and treatment T₄significantly recorded the lowest Number of leaves/plant (11.00 leaves).Similar findings were reported by Gerovacet *et al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Comment [OP12]: What was done differently in your study? What was the achievement/innovation to Kale cultivation?

Days to Leaves picking

Treatment T₂ produced higher Days of leaves picking 62.67 followed by treatment T₀ (66.67), treatment T₁ (68.67) treatment T₃ (69.00), treatment T₆ (69.33), T₄ significantly recorded the lower Days of leaves picking 75.00. Similar findings were reported by Gerovacet *al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Comment [OP13]: What was the technical criteria to pick de leaves, size? What size? Add bibliographic reference

Comment [OP14]: Confidence level or p-value?

Fresh weight of leaves

Treatment T₂ produced highest Fresh weight of leaves 24.40 g followed by treatment T₀(22.29 g), treatment T₁ (21.48 g), treatment T₃ (20.83 g), treatment T₆ (20.51 g), T₄ recorded significantly the lowest Fresh weight of leaves 14.48 g. Similar findings were reported by Gerovacet *al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Leaf yield/bag(g)

Treatment T₂ produced highest Leaf yield/bag 50.54g followed by treatment T₀ (45.57g), treatment T₁ (43.92g), treatment T₃ (42.96g), treatment T₆ (42.67g), T₄ significantly recorded the lowest Leaf yield/bag 23.22g. Similar findings were reported by Gerovacet *al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Comment [OP15]: The bad should be described in the methodology section

Leaves yield/hectare (Kg/ha)

Estimated leaves yield per hectare was observed in Treatment T₂ produced High Leaves yield/hectare 14.93 followed by treatment T₀ (14.91), treatment T₁(14.38), treatment T₃ (14.30), treatment T₆ (13.80), T₄ significantly recorded the lowest Leaves yield/hectare 10.49. Similar findings were reported by Gerovacet *al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Comment [OP16]: The sequence of light treatments is repeated from the previous sections of results (T₂, T₀, T₁, T₃, T₆, being T₄ the lowest of all real result discussion is missing why? How?

TSS

Treatment T₂ produced high TSS 3.23 °Brix followed by treatment T₀ (2.19 °Brix), treatment T₁ (1.72 °Brix), treatment T₇(1.58 °Brix), treatment T₆ (1.53 °Brix), T₄ recorded significantly the lowest TSS 0.51 °Brix. Similar findings were reported by Gerovacet *al.*, (2016) and Ying *et al.*, (2020) in Brassicas; Yao *et al.*, (2017) and Yao *et al.*, (2020) in rapeseeds; Zhang *et al.*, (2020) in Kale.

Shelf-life

Treatment T₂ produced high Shelf life 4.67 days followed by treatment T₀(4.00 days), treatment T₁ (3.67 days), treatment T₇ (3.33 days), treatment T₆(3.33 days), T₄ significantly recorded the lowest Shelf life 1.67 days.

Chlorophyll Content

Treatment T₂ produced high Chlorophyll content 56.40nmol cm² followed by treatment T₀ (52.54nmol cm²), treatment T₁(50.17nmol cm²), treatment T₇ (49.62nmol cm²), treatment T₆ (48.23nmol cm²), T₈ significantly recorded the lowest Chlorophyll content 40.39nmol cm².

Conclusion

Based on the findings of the present investigation, it is concluded that treatment T₂ (LED Tube White) performed best in respect to all other treatments for growth yield and quality of Kale under influence of light.

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Comment [OP17]: (T₂, T₀, T₁, T₃, T₆, being T₄ the lowest of all except for chlorophyll content, why????)

Comment [OP18]: Only 3 references are actually used in the text.....

Comment [OP19]: Not cited in the body text

Comment [OP20]: Not cited in the body text

Comment [OP21]: Not cited in the body text

Comment [OP22]: Not cited in the text

Comment [OP23]: Not cited in the text

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Comment [OP24]: Not cited in the text

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Comment [OP26]: Not cited in the text

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Comment [OP27]: Not cited :.....

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Comment [OP28]: Idem ...

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Comment [OP29]: idem

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Comment [OP30]:

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Table 2 Performance of Kale on different light treatments for different parameters.

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/plant	Days to leaves picking (number?)	Fresh weight of leaves (g)	Leaves yield/bag (g)	Yield per hectare (Kg/ha)	TSS [°Brix]	Shelf-life (number of 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

Comment [OP31]: acronyms used in the table should be explained. DAS_ days after sowing?

Comment [OP32]: To fully understand the table and result discussion, ANOVA and post-hoc results are missing, usually represented by letters after average (average followed by the same letter are similar....for example, for plant height after 15 days: T2 and T0 are statistically different?