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Performance of lettuce plants under organic mulch and LEDs light colors

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Abstract

This study was performed out at net house, privet farm, Cairo-Alexandria desert road, 80 Km, to present the positive role of using different types of organic mulch; different LEDs (light-emitting diodes) light colors and their combination on lettuce plants as growth and yield. Three types of organic mulch i.e., (mushroom wastes, compost and palm fibers) compared to bare soil and four LEDs light colors i.e., (white, yellow, green and "red + blue + green") plus natural light. Seedlings of lettuce cv. Iceberg were transplanting at 1st November through 2019 and 2020seasons. The study was conducted in a split plot design with three replications. Results obtained that using different types of organic mulch, different LEDs light colors and their combination had a significant overall tested parameters (plant length, number of leaves/head, fresh and dry weights of leaves, leaves contents from N, P and K and total heads yield/m^2). In general, cultivated lettuce plants with using different types organic mulch and different LEDs light colors enhanced all tested parameters compared to bare soil or/and natural light. The most positive role of tested factors was noticed with using compost mulch, LEDs "R + B+ G" colors and their combination as compost mulch plus LEDs "R + B+ G colors", which, had greatest values of all tested parameters more than other treatments.

Keywords: Lettuce; Organic mulch; LEDs light color; Head yield

1. Introduction

Lettuce (*Lactuca sativa* L.) is the most vegetable grown in greenhouses. It has characterized by short growth cycle, low energy demands, high mineral and physiologically active component concentrations, and a high and steady yield. Lettuce is a popular salad crop and one of the most important commercial vegetables in the world. It is an annual plant in the Asteraceae family [1]. In greenhouses, lettuce is the most commonly grown vegetable [2].

Organic mulching is the application of any plant residues or other materials to cover the top soil surface in order to conserve soil moisture, reduce runoff and thus manage soil erosion, control weed growth, improve soil temperature, and modify the soil micro environment to meet the needs of seeds for good germination and seedling growth. Mulching lowers temperature changes in the first 20–30 cm depth of soils, stimulates root improvement, reduces vegetative competition in the rooting zone, reduces fertilizer leaching and soil compaction, and produces cleaner vegetables because no soil is splashed onto the plants or fruits [3].

The Mediterranean environment is marked by significant annual organic material losses. Adding compost to soil is environmentally friendly, especially in poor fertility soils, as it increases soil fertility and improves crop yield. Using compost as organic mulch on lettuce plants, it enhances yield and nutrient content. Because the results of an experiment

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with arugula and lettuce showed that leafy vegetables respond well to organic manure, researchers concluded that organic matter mineralization helped to plants getting the nutrients they needed throughout development [4].

Now days, total mushroom production has expanded more than sixfold, from around 1.2 million metric tons in 1980 to nearly 7.3 million metric tons in 2010. Saw dust, banana leaves, peanut hulls, maize leaves and husks, sugarcane leaves, rice and wheat straw, cotton wastes, paper wastes, cocoa shells, wheat, and other agricultural wastes are among the natural resources used to make mushrooms around the world. Used mushroom substrates are usually abandoned or discarded at the conclusion of each manufacturing cycle. Because these minerals are generally harmless to plants, they could be used as a soil amendment for a variety of crops. These minerals could be utilized as a soil amendment for a number of crops because they are generally innocuous to plants. Mushroom wastes are a good soil amendment and conditioner, and adding them to a crop's soil has been shown to enhance output significantly. The addition of mushroom wastes to the soil improved tomato, lettuce, and radish yields. Many researches across the world have confirmed that employing mushroom wastes as organic mulch improves the productivity and quality of many vegetables and other horticultural products [5].

Light, temperature, CO_2 concentration, humidity, and other environmental conditions are considering vital factors influence on plant growth and development. For plant growth, light is a critical environmental component. Plants use photosynthesis to convert light energy into adenosine triphosphate (ATP) and nicotinamide adenine dinucleotide phosphate (NADPH) in light reactions [6].

When, natural light is insufficient for plant growth, artificial lighting is commonly utilized in greenhouses; in this case, supplemental lighting is primarily used throughout the winter. Artificial light sources utilized have a significant impact on energy consumption since plant growth necessitates the provision of lighting for several hours each day [7]. The spectral composition of the light source is also important for the quality and quantity of the vegetable produced, because light features influence plant development: plant growth is influenced not only by the amount of light reaching the leaf, which is usually calculated as the photosynthetic photon flux density (PPFD), but also by the light source's spectral composition [8].

Recently a light emitting diode (LED) has spread as a new light source. LED has good life performance, energy-saving ability and narrow bandwidth of wavelength. This narrow bandwidth characteristic enables to produce various light qualities, and the effects of light qualities on the growth and development of plant have been studied for a long time. Red light promotes germination and photosynthesis. Blue light effects stomatal opening and chloroplast development. Green light slows down or stops the plant development, but it brings positive effects in special conditions. In many plants and wavelength, the absorbance of leaves or the quantum yield of photosynthesis have been studied. We consider LED can produce the best light quality for plant growth in plant factories by combining the characteristic of bandwidth and plant growth and development [9]. White LED light photoperiod created favorable conditions for biomass production of all tested leafy greens. Fresh weights of plants grown under supplementary white LED light were the highest [10].

On other word, increasing photosynthesis and plant growth, light supplementation can improve crop productivity. LEDs are a promising technology with a lot of potential for improving irradiance efficiency and replacing traditional horticultural lighting [11]. Furthermore, plant development is influenced by light quality through the three activation types of photoreceptors: (i) phytochromes, (ii) cryptochromes, and (iii) phototropins, which regulate physiological and morphological responses. Also, plants require different parts of the luminous spectrum to accomplish key processes; hence the spectral composition of light is critical for proper plant growth [7].

In Egypt, protected cultivation sector facing a series problems first one organic waste has long been seen as a pollutant, with little consideration given to it as a by-product of agricultural activity that may be composted to make organic fertilizers [12]. Which, the second low natural light, especially, when, using old net or plastic covers. In addition, low natural light conditions are common on consecutive wet days, early spring, and winter, while high light intensity is common in late spring and early autumn [13].

This investigation is aiming to identify vegetative growth and total yield performances of lettuce plants for using different organic mulch types and different LED light colors and their combination.

2. Material and methods

2.1. Experimental layout

This experiment was conducted out at net house located at the privet farm, Cairo-Alexandria desert road, 80 Km. Two main factors were tested in this experiment as follow:

- Factor (A): using three types of organic mulch i.e., (mushroom wastes, compost and palm fibers) compared to bare soil.
- Factor (B): using four LEDs (light-emitting diodes) light colors i.e., (white, yellow, green and "red + blue + green"), plus natural light.

Physical and chemical characteristics of mushroom wastes and Nile compost presented in Tables (1 and 2).

Table 1 chemical characteristic of mushroom wastes

Mushroom wastes properties	Values
PH	6.10
EC (dS/m)	1.331
Total nitrogen (%)	0.34
Phosphorus (%)	0.16
Potassium (%)	0.53
Calcium (%)	0.51
Manganese (%)	0.15

Table 2 Physical and chemical properties of Nile compost

Compost properties	Values
Density as wet basis (kg/m^3)	600 - 750
Density as dry basis (kg/m^3)	450 - 560
Moisture content (%)	25 - 30
pH in 1: 10 extracts	5.5 - 7.5
EC in 1: 10 extracts (dS/m)	3.5 - 5.5
Water holding capacity (%)	200 - 300
Organic matter (%)	40 - 45
Organic carbon (%)	23.2 - 26.1
C/N ratio	14.5:1 - 16.5:1
Total nitrogen (%)	1.4 - 1.8
Phosphorus (%)	0.4 - 0.8
Potassium (%)	0.6 - 1.2
Iron (ppm)	1500 - 2000
Copper (ppm)	160 - 240
Manganese (ppm)	100 - 150
Zinc (ppm)	40 - 80

2.2. Net house preparation

A net house 360m^2 (9m width, 40m length, and 3.2m height), included five raised beds. Each bed had 1m width and 40m long. Seedlings of Lettuce plants (*Lactuca sativa* cv. Iceberg) were transplanted in 1st of November during 2019 and 2020 seasons, with spacing of 0.25m between plants inside the same raw. Chemical fertilizers were added according to the recommendation of the Ministry of Agriculture. Organic mulch (1cm thickness) was used as soil mulch. Drip irrigation system was used. LEDs light colors were fixed over plants by 0.25m. Lighting is starting every day from 5 pm to 5 am.

2.3. Treatments

Three types of organic mulch i.e., (mushroom wastes, compost and palm fibers) compared to bare soil, four LEDs light colors i.e., (white, yellow, green and "red + blue + green"), plus natural light and their combination were used as treatments as shown.

- Mushroom wastes as organic mulch,
- Compost as organic mulch,
- Palm fibers as organic mulch,
- Bare soil as control,
- LED light white color (LED W color),
- LED light yellow color (LED Y color),
- LED light green color (LED G color),
- LEDs light "red + blue + green" color (LEDs "R + B + G" colors) and
- Natural light as control.

2.4. Measurements

Three plants were selected at random from each plot after 60 days from transplanting. That parameter (plant length, number of leaves/head, fresh and dry weights of leaves and total heads yield/m^2) were recorded at sample plants. Also, total N, P and K contents of leaves were determined for each treatment according to distillation in a Macro-Kjeldahle apparatus, atomic absorption spectrophotometric methods and flame photometer as described by FAO [14].

2.5. Experimental design and data analysis

With three repetitions, the study was conducted in a split plot design. In the main plots, the various types of organic mulch treatments were arranged, while in the sub plots, the various LED light colors were arranged. The analysis of variance approach was used to statistically assess the data obtained. Duncan's multiple range tests were used to compare mean values at a 5% level of probability [15].

3. Results

Results presented in Tables (from 3 to 10), reflected the positive role of cultivated plants under different types of organic mulch and different LEDs light colors on vegetative tested parameters such as (plant length, number of leaves/head, fresh and dry weights of leaves and total heads yield/m^2) compared to check treatment.

3.1. Plant length

Data in Table (3), indicated that using compost treatments as organic mulch led to increase plant lengths more than other treatments. Moreover, mushroom wastes and palm fibers ranked as second and third places, respectively. When, bare soil treatment declined lettuce plant length.

In other word, the improved plant length of lettuce was observed generally with using different LEDs light colors. The highest plant length noticed with LEDs "R + B + G" colors treatment followed by LED W color and LED G color treatments, respectively, without any significant difference. While using LED Y color treatment reduced plant length of lettuce plants followed in less order by natural light treatment.

Cultivated lettuce plant under compost mulch plus LEDs "R + B + G" colors treatment as combination between different types of organic mulch and different LEDs light colors produced the greatest plant length among other treatments. While, bare soil + natural light treatment decreased this parameter. This trend was indicated in both growing seasons.

Table 3 Positive role of using different organic mulch types and different LEDs light colors on plant length (cm) of lettuce during seasons 2019/2020 and 2020/2021.

LEDs light colors	Organic mulch types				
	Mushroom wastes	Compost	Palm fibers	Bare soil	Mean
	First season				
LED W color	19.45^{d}	21.38^{b}	17.32^{f}	15.66^{h}	18.45^{B}
LED Y color	15.76^{h}	17.59^{ef}	13.68^{j}	12.15^{k}	14.80^{C}
LED G color	18.24^{e}	20.61^{c}	16.54^{g}	14.53^{i}	17.48^{B}
LEDs "R + B + G" colors	21.67^{b}	23.37^{a}	19.33^{d}	17.09^{fg}	20.37^{A}
Natural light	13.55^{j}	14.51^{i}	12.25^{k}	11.06^{l}	12.84^{D}
Mean	17.73^{B}	19.49^{A}	15.82^{C}	14.10^{D}	
	Second season				
LED W color	18.28^{d}	20.10^{b}	16.28^{f}	14.72^{h}	17.35^{B}
LED Y color	14.81^{h}	16.53^{ef}	12.86^{j}	11.42^{k}	13.91^{C}
LED G color	17.15^{e}	19.37^{c}	15.55^{g}	13.66^{i}	16.43^{B}
LEDs "R + B + G" colors	20.37^{b}	21.97^{a}	18.17^{d}	16.06^{fg}	19.14^{A}
Natural light	12.74^{j}	13.64^{i}	11.52^{k}	10.40^{l}	12.07^{D}
Mean	16.67^{B}	18.32^{A}	14.87^{C}	13.25^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

3.2. Number of leaves/head

Table 4 Positive role of using different organic mulch types and different LEDs light colors on leaves number/head of lettuce during seasons 2019/2020 and 2020/2021

	Organic mulch types				
LEDs light color	Mushroom wastes	Compost	Palm fibers	Bare soil	Mean
	First season				
LED W color	44.70^{c}	47.59^{b}	41.32^{d}	38.52^{f}	43.03^{B}
LED Y color	34.86^{h}	36.64^{g}	31.37^{j}	28.19^{l}	32.77^{D}
LED G color	39.93^{e}	41.49^{d}	35.54^{h}	33.47^{i}	37.61^{C}
LEDs "R + B + G" colors	47.84^{b}	48.95^{a}	44.74^{c}	41.79^{d}	45.83^{A}
Natural light	31.28^{j}	33.57^{i}	29.53^{k}	26.37^{m}	30.19^{E}
Mean	39.72^{B}	41.65^{A}	36.50^{C}	33.67^{D}	
	Second season				
LED W color	42.47^{c}	45.21^{b}	39.25^{d}	36.59^{f}	40.88^{B}
LED Y color	33.12^{h}	34.81^{g}	29.80^{j}	26.78^{l}	31.13^{D}
LED G color	37.93^{e}	39.42^{d}	33.76^{h}	31.80^{i}	35.73^{C}
LEDs "R + B + G" colors	45.45^{b}	46.50^{a}	42.50^{c}	39.70^{d}	43.54^{A}
Natural light	29.72^{j}	31.89^{i}	28.05^{k}	25.05^{m}	28.68^{E}
Mean	37.74^{B}	39.57^{A}	34.68^{C}	31.98^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

Data Illustrated in Table (4) show, the enhanced number of leaves/head of lettuce plants by using different types of organic mulch and different LEDs light colors. The greatest number of leaves per head was obtained with plants cultivated in compost mulch treatment followed in less order by mushroom wastes and palm fibers, respectively. When, bare soil presented the lowest number of leaves per head.

LEDs "R + B + R" colors treatment encouraged lettuce plants to give highest number of leave per head. Moreover, LED W color, LED G color and LED Y color occupied the second, third and fourth placed, respectively, in less order of number of leaves/head values. While, natural light recoded the lowest value from number of leaves per head

Conserving the combination between different types of organic mulch and different LEDs light colors the positive role on number of leaves/head was found with compost mulch plus LEDs "R + B + G" colors treatment more than other treatments. In addition, bare soil + natural light gave lowest number of leaves/head. Same results were obtained in both tested seasons.

3.3. Fresh and dry weights

Presented data in Tables (5 and 6) obtained that, in general, using different types of organic mulch improved fresh and dry weights of lettuce plants. The greatest positive role of different types of organic mulch noticed with compost mulch treatment, which recorded the highest values from fresh and dry weights, followed in less order by mushroom wastes and palm fibers treatments, respectively. When, bare soil treatment was obtained the lowest values of their parameters.

On other hand, cultivation lettuce plants under different LEDs light colors increased fresh and dry weights compared to natural light treatment. The greatest fresh and dry weights of lettuce plants values were observed in less order with LEDs "R + B + G" colors, LED W color, LED G color and LED Y color treatments, respectively. Although, natural light treatment recoded the lowest values.

Regarding to combination compost mulch plus LEDs "R + B + G" colors treatment led to encouraged fresh and dry weights of lettuce plants among other treatments. While, bare soil + natural light treatment were declined it. This result noticed in both tested seasons.

Table 5 Positive role of using different organic mulch types and different LEDs light colors on head fresh weight (g) of lettuce during seasons 2019/2020 and 2020/2021.

	Organic mulch types				
LEDs light colors	**Mushroom wastes**	**Compost**	**Palm fibers**	**Bare soil**	**Mean**
	First season				
LED W color	580^{c}	620^{b}	500^{f}	475^{g}	543.75^{B}
LED Y color	445^{i}	500^{f}	375^{l}	325^{m}	411.25^{D}
LED G color	498^{f}	566^{d}	445^{i}	415^{j}	481.00^{C}
LEDs "R + B + G" colors	620^{b}	670^{a}	580^{c}	540^{e}	602.50^{A}
Natural light	390^{k}	460^{h}	310^{n}	279^{o}	359.75^{E}
Mean	506.60^{B}	563.20^{A}	442.00^{C}	406.80^{D}	
	Second season				
LED W color	568^{c}	608^{b}	490^{f}	466^{g}	532.88^{B}
LED Y color	436^{i}	490^{f}	368^{l}	319^{m}	403.03^{D}
LED G color	488^{f}	555^{d}	436^{i}	407^{j}	471.38^{C}
LEDs "R + B + G" colors	608^{b}	657^{a}	565^{c}	529^{e}	589.60^{A}
Natural light	382^{k}	451^{h}	304^{n}	273^{o}	352.56^{E}
Mean	496.47^{B}	551.94^{A}	432.48^{C}	398.66^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

Table 6 Positive role of using different organic mulch types and different LEDs light colors on head dry weight (g) of lettuce during seasons 2019/2020 and 2020/2021

	Organic mulch types				
LEDs light colors	**Mushroom wastes**	**Compost**	**Palm fibers**	**Bare soil**	**Mean**
	First season				
LED W color	26.38^{e}	29.32^{c}	23.69^{g}	21.51^{i}	25.23^{B}
LED Y color	17.64^{m}	19.86^{k}	15.48^{n}	13.76^{o}	16.69^{D}
LED G color	22.39^{h}	24.25^{f}	20.72^{j}	18.54^{l}	21.48^{C}
LEDs "R + B + G" colors	31.73^{b}	34.67^{a}	28.83^{d}	26.22^{e}	30.36^{A}
Natural light	13.86^{o}	14.20^{o}	13.09^{p}	12.55^{r}	13.43^{E}
Mean	22.40^{B}	24.46^{A}	20.36^{C}	18.52^{D}	
	Second season				
LED W color	25.59^{e}	28.44^{c}	22.98^{g}	20.86i	24.47^{B}
LED Y color	17.11^{m}	19.26^{k}	15.02^{n}	13.35^{o}	16.18^{D}
LED G color	21.72^{h}	23.52^{f}	20.10^{j}	17.98^{l}	20.83^{C}
LEDs "R + B + G" colors	30.78^{b}	33.63^{a}	27.97^{d}	25.43^{e}	29.45^{A}
Natural light	13.44^{o}	13.77^{o}	12.70^{p}	12.17^{r}	13.02^{E}
Mean	21.73^{B}	23.73^{A}	19.75^{C}	17.96^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

3.4. Nitrogen, phosphorus and potassium contents in leaves

Data illustrated in Tables (7, 8 and 9) obtained that lettuce plants which cultivated with different types of organic mulch treatments increased N, P and K treatments contents in lettuce leaves more than bare soil treatment.

Furthermore, the highest values of N, P and K contents in lettuce leaves observed with using compost mulch treatment followed in less order by mushroom wastes and palm fibers treatments, respectively. Whereas, lettuce plants cultivated in bare soil treatment reduced it.

Moreover, using different LEDs light colors enhanced contents lettuce leaves from N, P and K. the greatest values of N, P and K contents in lettuce leaves were noticed with LEDs "R + B + G" colors treatment followed by LED W color and LED G color and LED Y color treatments, which, ranked as second, third and fourth placed, respectively. When, lowest values of N, P and K contents in leaves observe with natural light treatment.

In addition, combination between using different organic mulch types and different LEDs light colors noticed that compost mulch plus LEDs "R + B + G" colors treatment increased N, P and K contents in leaves among other treatments. When, bare soil + natural light treatment reduced contents leaves from N, P and K. This Trend was true in both tested seasons.

3.5. Total heads yield/m^2

Presented data in Table (10) show that using tested factors throughout two growth seasons affected significantly on total yields of head lettuce plants/m^2. The heavy production of total heads yield/m^2 was obtained with compost mulch treatment followed in less order by the mushroom wastes and palm fibers treatments, respectively. The bare soil treatment had the lowest total heads yield/ m^2 of lettuce plants.

Furthermore, generally, different LEDs light colors led to improve total yield of heads/m^2. Cultivated plants under LEDs "R + B + G" colors treatment produced greatest overall total heads yield/m^2 from lettuce plants.

Table 7 Positive role of using different organic mulch types and different LEDs light colors on nitrogen content (%) in leaves of lettuce during seasons 2019/2020 and 2020/2021

	Organic mulch types				
LEDs light colors	**Mushroom wastes**	**Compost**	**Palm fibers**	**Bare soil**	**Mean**
	First season				
LED W color	2.47^{f}	2.81^{c}	2.31^{g}	2.14^{i}	2.43^{B}
LED Y color	1.78^{k}	1.89^{j}	1.46^{n}	1.29^{p}	1.61^{D}
LED G color	2.18^{h}	2.34^{g}	1.87^{j}	1.51^{m}	1.98^{C}
LEDs "R + B + G" colors	2.91^{b}	3.02^{a}	2.75^{d}	2.52^{e}	2.80^{A}
Natural light	1.51^{m}	1.68^{l}	1.37^{o}	1.11^{r}	1.42^{E}
Mean	2.17^{B}	2.35^{A}	1.95^{C}	1.71^{D}	
	Second season				
LED W color	2.45^{f}	2.78^{c}	2.29^{h}	2.12^{j}	2.41^{B}
LED Y color	1.76^{m}	1.87^{k}	1.45^{p}	1.28^{s}	1.59^{D}
LED G color	2.16^{i}	2.32^{g}	1.85^{l}	1.49^{o}	1.96^{C}
LEDs "R + B + G" colors	2.88^{b}	2.99^{a}	2.72^{d}	2.49^{e}	2.77^{A}
Natural light	1.49^{o}	1.66^{n}	1.36^{r}	1.10^{t}	1.40^{E}
Mean	2.15^{B}	2.32^{A}	1.93^{C}	1.70^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

Table 8 Positive role of using different organic mulch types and different LEDs light colors on phosphorus content (%) in leaves of lettuce during seasons 2019/2020 and 2020/2021

	Organic mulch types				
LEDs light colors	**Mushroom wastes**	**Compost**	**Palm fibers**	**Bare soil**	**Mean**
	First season				
LED W color	0.45^{c}	0.48^{b}	0.42^{de}	0.40^{efg}	0.44^{B}
LED Y color	0.39^{fgh}	0.41^{ef}	0.36^{hi}	0.34^{ij}	0.38^{D}
LED G color	0.42^{de}	0.44^{cd}	0.40^{efg}	0.38^{gh}	0.41^{C}
LEDs "R + B + G" colors	0.49^{b}	0.52^{a}	0.48^{b}	0.45^{c}	0.49^{A}
Natural light	0.35^{ij}	0.38^{gh}	0.33^{j}	0.30^{k}	0.34^{E}
Mean	0.42^{B}	0.45^{A}	0.40^{C}	0.37^{D}	
	Second season				
LED W color	0.44^{c}	0.47^{b}	0.41^{d}	0.39^{ef}	0.43^{B}
LED Y color	0.38^{fg}	0.40^{de}	0.35^{h}	0.33^{ij}	0.37^{D}
LED G color	0.41^{d}	0.43^{c}	0.39^{ef}	0.37^{g}	0.40^{C}
LEDs "R + B + G" colors	0.48^{b}	0.51^{a}	0.47^{b}	0.44^{c}	0.48^{A}
Natural light	0.34^{hi}	0.37^{g}	0.32^{j}	0.29^{k}	0.33^{E}
Mean	0.41^{B}	0.44^{A}	0.39^{C}	0.37^{D}	

Table 9 Positive role of using different organic mulch types and different LEDs light colors on potassium content (%) in leaves of lettuce during seasons 2019/2020 and 2020/2021

LEDs light colors	Organic mulch types				
	Mushroom wastes	Compost	Palm fibers	Bare soil	Mean
	First season				
LED W color	2.26^{d}	2.31^{c}	2.18^{e}	1.97^{g}	2.18^{B}
LED Y color	1.72^{k}	1.93^{h}	1.54^{m}	1.32^{o}	1.63^{D}
LED G color	1.92^{h}	2.16^{f}	1.66^{l}	1.28^{p}	1.76^{C}
LEDs "R + B + G" colors	2.34^{b}	2.58^{a}	2.15^{f}	1.89^{i}	2.24^{A}
Natural light	1.52^{n}	1.74^{j}	1.27^{p}	1.12^{r}	1.41^{E}
Mean	1.95^{B}	2.14^{A}	1.76^{C}	1.52^{D}	
	Second season				
LED W color	2.21^{d}	2.26^{c}	2.14^{e}	1.93^{g}	2.14^{B}
LED Y color	1.69^{k}	1.89^{h}	1.51^{m}	1.29^{o}	1.59^{D}
LED G color	1.88^{h}	2.12^{f}	1.63^{l}	1.25^{p}	1.72^{C}
LEDs "R + B + G" colors	2.29^{b}	2.53^{a}	2.11^{f}	1.85^{i}	2.20^{A}
Natural light	1.49^{n}	1.71^{j}	1.24^{p}	1.10^{r}	1.38^{E}
Mean	1.91^{B}	2.10^{A}	1.72^{C}	1.49^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

Table 10 Positive role of using different organic mulch types and different LEDs light colors on total heads yield (g)/m^{2} of lettuce during seasons 2019/2020 and 2020/2021

LEDs light colors	Organic mulch types				
	Mushroom wastes	Compost	Palm fibers	Bare soil	Mean
	First season				
LED W color	4640^{c}	4960^{b}	4000^{f}	3800^{g}	4350^{B}
LED Y color	3560^{i}	4000^{f}	3000^{l}	2600^{m}	3290^{D}
LED G color	3984^{f}	4528^{d}	3560^{i}	3320^{j}	3848^{C}
LEDs "R + B + G" colors	4960^{b}	5360^{a}	4640^{c}	4320^{e}	4820^{A}
Natural light	3120^{k}	3680^{h}	2480^{n}	2232^{o}	2878^{E}
Mean	4053^{B}	4506^{A}	3536^{C}	3254^{D}	
	Second season				
LED W color	4547^{c}	4861^{b}	3920^{f}	3724^{g}	4263^{A}
LED Y color	3489^{i}	3920^{f}	2940^{l}	2548^{m}	3224^{D}
LED G color	3904^{f}	4437^{d}	3489^{i}	3254^{j}	3771^{C}
LEDs "R + B + G" colors	4861^{b}	5253^{a}	4547^{c}	4234^{e}	4724^{A}
Natural light	3058^{k}	3606^{h}	2430^{n}	2187^{o}	2820^{E}
Mean	3972^{B}	4415^{A}	3465^{C}	3189^{D}	

* Alphabetic inside the table refers to analysis of variance of statistically assess the data.

On the other hand, LED W color, LED G color and LED Y color treatments were ranked as second, third and fourth, respectively. In both seasons tested, the changes in LEDs light colors treatments were considerable. Although, natural light led to shortage total heads yield/m^2 from lettuce plants.

Moreover, combination between using different types of organic mulch and different LEDs light colors had a positive impact on the total heads yield/m^2 of lettuce plants. Compost mulch plus LEDs "R + B + G" colors treatment produced the highest total heads yield/m^2 among other treatments. When, bare soil + natural light treatment was reduced it.

4. Discussion

In this investigation, statistical analysis of all tested mentioned before reflected the positive impact of using different types of organic mulch, different LEDs (light-emitting diodes) light colors and their combination on lettuce plants.

Generally, covering soil surface by organic mulch types i.e., (mushroom wastes, compost and palm fibers) improved almost lettuce plant parameters such as (plant length, number of leaves/head, fresh and dry weight of leaves per head, leaves contents from N, P and K and total heads yield/m^2). The most positive role of organic mulch types was obtained with compost mulch treatment followed in less order by mushroom wastes and palm fibers treatments, respectively compared to bare soil treatment. This enhanced may be due to increasing the available soil moisture which in turn may increase the absorption of water and the uptake of the nutritional elements thus causing favorable condition for the physiological processes needed for plant growth [3]. Furthermore, following decomposition of organic mulch types return their contents from organic matter and plant nutrients to the soil, which, improve the physical, chemical, and biological qualities of the soil those led to increasing crop production. Also, the soil beneath the mulch is still loose and friable. Aeration and microbiological activity in the soil are improved. Organic mulches also reduced bulk density in heavy black soil as compared to the control. Organic mulches not only conserve soil moisture, but they also add nutrients to the soil by adding organic matter [16].

Mulching increased soil moisture and organic matter content, allowing roots to penetrate more easily. Mulching, according to Ghuman and Sur [17], reduces the bulk compactness of the surface soil. Because of the degradation of the mulch, the soil organic matter increased. When more mulch was applied, organic matter was considerably higher, according to Khurshid *et al.* [18]. Mulched treatments exhibited considerably better overall uptake of nitrogen, phosphate, and potassium than similar un-mulched treatments, according to Muhammad *et al*. [19].

Our indicated about increased vegetative growth parameters with organic mulch types are consistent with those reported by Awodoyin *et al*. [20]. Who, observed that mulching the soil surface boosted plant height significantly as compared to bare soil, possibly due to the higher soil warmth, and studies on plant growth revealed that the mulched plots' plants were generally taller and more vigorous than the un-mulched plots.

According to Norman *et al.* [21] and Sadek *et al*. [3] the organic mulch had a greater impact on the number of leaves/plant than the control (bare soil) treatment. Moreover, these findings are consistent with Hong *et al*. [22], who discovered that the foliage weight was higher with mulching materials than without. Foliage growth is stimulated by mulching with wastes and reflective film. Organic mulches, according to Matsenjwa [23], boosted vegetative growth. Kumar *et al*. [24], observed that dry weight (g/plant) was significantly higher in plots mulched with organic mulch, owing to the high amount of organic matter in the form of leaf biomass in organic mulch [25]. Das [26], has also reported on the benefits of mulching on growth and dry matter production. In addition, Kumar and Lal [16] suggested that increased plant dry weight for mulched plants is owing to mulch's ability to retain soil moisture as well as increased plant water uptake efficiency.

On other hand, in comparison to bare soil, organic mulch treatments were the most beneficial application for encouraging plant growth as measured by plant length, number of leaves/head, and fresh and dry weights of leaves. It's possible that the beneficial effect of organic mulch on total plant growth performance is related to the fact that mulched plants grow better more than plants grown in bare soil ([27], [3]). Many others have demonstrated similar advances in field-grown plant materials. Plant height and/or number increases have all been recorded as a result of mulching using the right materials. Organic materials are the best mulches for overall plant performance, frequently recognized as the top or second best in comparative field studies ([28], [29]). Rapid decomposers like grass clippings, leaves, and compost [30], moderate decomposers like paper, hay, straw, and other crop wastes, and slow decomposers like bark and woody chips have all been tested [28].

The impacts of mulches on plants are mediated through their effects on soil water and temperature structure. Mulch helps to reduce evaporation, which is one of the main reasons for plant development. Mulching creates an ideal growing environment. Plants that are more vigorous and healthier are the consequence of a mix of the aforementioned, as well as maybe other variables. Mulched plants, on the other hand, tend to grow and mature more consistently than un-mulched plants. Different mulching materials were shown to have a significant impact on growth characteristics. Root growth is stimulated by increased soil temperature and moisture content, which led to increased plant growth [31], [32], [3].

Refer to, increasing lettuce leaves contents from N, P and K, this trend is harmony with [19], [24], and [3] indicated that mulched treatments have considerably higher total nitrogen, phosphorus, and potassium uptake than un-mulched treatments. The immobilization of soil N by soil bacteria produced by a high C: N ratio results in limited performance beneath mulch. Organic mulches increased the nutrients and structure of the soil [33]. The decomposition of organic mulch results in enhanced nutrient availability and soil organic matter for plant usage. Straw, wood chips and sawdust mulches have high carbon to nitrogen ratios, according to Rose [34].

Furthermore, mulches with a high nitrogen level frequently result in higher yields, whereas mulches with low nitrogen content can improve soil fertility and plant nutrition. Straw, sawdust, and mulches, for example, have been demonstrated to boost nutrient levels in soil and/or foliage. Similarly, when compared to grasses and leaf litter, which presumably have higher nitrogen levels, compost mulch was most effective in boosting accessible soil nutrients [35].

Regarding to total yield, applying organic mulch type's treatment in general and compost mulch treatment especially, led to produce heavy total heads yield/m^2. Same results are reported that mulching increased fruit output, which, is an indication that mulching is more helpful to crop performance. Mulches consistently improved yield attributes as compared to non-mulch applications [20], [36], [3].

The yield was found to be improved. Organic mulch can help increase vegetable yield and quality of storage. This is most likely owing to improved plant development, which is influenced by stable soil temperatures and soil moisture [3]. Enhanced soil moisture retention, the establishment of a favorable soil temperature, improved soil structure, elevated nutritional status in soil, and well-developed root systems all contributed to a considerable increase in production [16]. Mulch increased the amount of vegetation and productivity of several crops, according to [3]. Increased yields could be ascribed to better growing conditions as moisture in the soil and nutrient use.

Mulch's most prevalent reaction is an increase in total yield. The mulched area produced significantly more marketable fruit than the bare soil plot. Moisture conservation, greater soil temperature, and increased mineral nutrient uptake in the mulched plot due to improved root temperatures can all be ascribed to this difference [3].

Mulches altered the microclimate by changing soil temperature, moisture, and evaporation, and the tailored microclimate had an impact on yield contributing factors. When a crop was grown with straw mulch, the fruit weight and overall yield were higher than when the same was grown without it [3]. Organic mulch grew higher when there was more mulch on the ground, owing to the availability of more soil moisture for plant growth. In comparison to control plots, Shashidhar *et al*. [37] found that paddy straw mulched plots produced the highest total leaf yield of mulberry. According to Khurshid *et al*. [18], crop residue mulching improved both the physical and chemical qualities of the soil while also preserving yield. The difference in growth and yield features found between mulched and un-mulched plots could be related to the mulched plots' larger soil moisture reserves, as increased soil moisture is known to improve fertilizer efficiency.

Pointed to compost mulch treatment recorded the greatest values of overall tested parameters more than mushroom wastes and palm fibers attributed to rapid decomposers led to enhance nutrient availability and soil organic matter for plant usage, improve highest total nitrogen, phosphorus, and potassium uptake, which, effective in boosting accessible soil nutrients and increasing and saving soil moisture.

On other wise, cultivating lettuce plants under different LEDs (light-emitting diodes) light colors i.e., ("red + blue + green", white, green and yellow) had positively affect at almost indicated characteristics (plant length, number of leaves/head, fresh and dry weight of leaves per head, leaves contents from N, P and K and total heads yield/m^2) more than natural light. The favorable effect of LEDs light colors was obtained with applying LEDs light "red + blue + green" colors treatment among all studied treatments. Other LEDs light colors treatments are arranged in less order as follow LED white color, LED light green color and LED light yellow color, respectively.

Regarding the positive impact of LEDs light colors attributes to the relative ratio of green (500 to 600 nm), red (600 to 700 nm), and blue (400 to 500 nm) light was the largest spectral waveband difference in the photosynthetic photon flux (PPF) region. Ohashi-Kaneko *et al*. [38], reported that, when red and blue light were supplemented with green light dry matter production was increased more than when white light was used. Kim *et al*. [39],who mentioned that the greatest lettuce growth Characteristics were noticed with lettuce plants grown under red, blue and green LEDs followed by red, blue LEDs. This suggests that the red, blue, and green light mixing ratio is critical for generating better leaf lettuce development. That is due to plants could grow and complete their life cycles using only red LEDs, but when red LEDs were supplemented with modest amounts of blue light, growth and development were considerably improved. Because blue LEDs were not readily accessible at the time, early research used red LEDs (660 nm) in combination with blue [40]. Also, Cope *et al*. [41] described the potential variables that limit the RQE (relative quantum efficiency) of blue light for photosynthesis by (1) non-photosynthetic pigments (e.g. anthocyanins) absorb around 20% of blue photons, and (2) some blue photons are absorbed by auxiliary pigments (such as carotenoids), which are 10 to 65 percent less efficient at transferring light energy to the photosynthetic reaction center than chlorophyll molecules. Increases in the amount of blue light can boost single-leaf photosynthetic capacity and efficiency up to a species- or cultivar-specific threshold, according to Hogewoning *et al*. [42]. Through the action of cryptochrome and phototropin photoreceptors, blue light is also known to impact leaf stomatal aperture, regulate chloroplast formation, and control photomorphogenic and phototrophic plant responses [40]. According to several researches, 5 to 20% blue light in the total photosynthetic photon flux (PPF) is required to increase growth and development while minimizing damage in controlled conditions, shade-avoidance responses (elongated internodes, petioles, and hypocotyls, larger, thinner leaves, reduced chlorophyll production, and early flowering [43].

Moreover, because of the low absorption by chlorophyll pigments, green (500–600 nm) is typically overlooked as a beneficial waveband for photosynthesis. However, studies show that it can have positive direct and indirect impacts on plant growth and photosynthesis [40]. In addition, for two main reasons, the use of red LED light to fuel photosynthesis has gained widespread acceptance. Plant pigments absorb red wavelengths (600 to 700 nm) efficiently; second, early LEDs were red, with the most efficient emitting at 660 nm, close to a chlorophyll absorption peak [44].

Because chlorophyll absorbs red and blue photons efficiently, most red and blue light is absorbed within a few cell layers of the leaf surface, whereas green photons can penetrate deeper into the leaf [45]. Sun *et al*. [46] discovered that red and blue light stimulate CO_2 fixation largely in the upper palisade mesophyll of the chloroplast, whereas green light stimulates CO_2 fixation in the lower palisade. Also, Terashima *et al*. [47] found that, once the upper chloroplasts of individual leaves have been saturated by white light, additional green light can increase photosynthesis by penetrating deeper into the leaf and driving CO_2 fixation in inner chloroplasts that have not been light-saturated by white light. Green light has also been demonstrated to penetrate further into the foliar canopy than red or blue light, allowing it to boost whole-plant photosynthesis by increasing CO_2 fixation in the inner and lower canopy leaves [39], [48]. Furthermore, the RQE of absorbed broadband green light can be comparable to that of red and higher than that of blue, depending on the species [40]. Another advantage of green LEDs, especially when combined with narrowband red and blue LEDs to create white light, is that they allow for a better visual assessment of plant state and true leaf color, which is difficult to detect when plants are only exposed to purple light from red and blue LEDs.

Furthermore, according to Kim *et al*. [39] noticed that the highest plant growth was achieved using red and blue LEDs with a green light treatment (RGB). It was impossible to assess the contribution of green light transmission into the lower canopy, since the lettuce plants were harvested before the canopy closed, spectral quality alterations were minimized. Because green light penetrates the plant canopy better than red or blue light, adding green light to a dense canopy may boost plant growth even more. Lower canopy leaves would be able to exploit the transmitted green light for photosynthesis, potentially reducing leaf senescence and/or shedding levels within the canopy. The addition of 5% green light had no effect on plant growth or photosynthesis. Green light is only slightly less effective at photosynthesis than red or blue light and drives carbon fixation deep into leaves, thus this was partly expected. Although, plant development was slowed when extra green light was added at higher input levels. That is mean, when the green light portion at LEDs was increased to 30% lettuce growth was reduced in terms of leaf area and dry weight. This meant that light sources with a large proportion of green photons should be avoided.

Moreover, Mitchell and Stutte [49] claim that there is no unique light-quality recipe that works for all species and stages of plant development. A combination of red and blue LEDs, on the other hand, can normally drive photosynthesis and regulate vegetative development in most plants. Plants must balance leaf area expansion (to maximize radiation collection) with stem elongation and reproductive growth, as Cope and Bugbee [43] argue, and the optimal light spectrum for plant growth and development fluctuates with plant age.

On other hand, plant leaves absorb red and blue light effectively, and the combination of red and blue light has been described as an effective lighting source in the development of a variety of crops [50]. However, white LED light was composed of a mixture of red, blue, and green light, more than half of the total light was composed of green light, which could penetrate the plant canopy more deeply than red and blue light, white LED light was more efficient in increasing fruits fresh weight than red LED light [48]. Also, According to Johkan *et al*. [51], using green light (PPF "photosynthetic photon flux" ≥ 300) alone is sufficient to achieve normal growth in lettuce plants. Maiza and Kurnia [52] mentioned that using a combination of two light sources was effective more than using one light source and using white LED light had a better effect on growth plants because of the complete spectrum of visible light. Plants can thrive under lighting that has all of the wavelengths that they require. In other word, white LED provides a variety of wavelengths that are efficiently utilized in plant light conversion processes. White LED (which includes green light and other wavelengths) has been found to be a reliable light source in lettuce plants that increases photosynthesis, growth and quality [53].

In same way, Liu *et al*. [54] reported that under the combined LEDs light treatment, lettuce plants had greater levels of N, P, and K. In fact, photosynthesis and nutrient element absorption rates are completely dependent on nutrient element content and accumulation. Also, overall, the fresh and dry weight of the lettuce plants was increased under combination LEDs light color treatment [55].

Spot on, using LEDs "R + B + G" colors treatment achieving the highest and values of tested vegetative growth parameters i.e., (plant length, number of leaves/head, fresh and dry weight of head), and heaviest total heads yield/m^2 among other applying LEDs i.e., (white, green and yellow) colors treatments. This improving due to Lettuce plants absorb the energy of LEDs R, B, and G colors and use it to make adenosine triphosphate (ATP) and nicotinamide adenine dinucleotide phosphate (NADPH) as light reactions. As a result, CO_2 is fixed as carbohydrates, while O_2 is created through light-independent processes. Their digestion of plant carbon is more efficient, and they enhance the activity of carbon assimilation enzymes, which increases the net photosynthetic rate and electron transport rate (ETR).

Rather than, LED W color treatment placed the second-place cause white LED is manufactured from blue LEDs and phosphors, the efficiency of blue LEDs has improved, allowing for more efficient white LED. Therefore, the white LED light was made up of a mixture of red, blue, and green light, more than half of the total light was made up of green light, the efficiency of white LED was higher than that of red LED that is able to penetrate deeper into the plant canopy than other LEDs color treatments.

5. Conclusion

From statistical analysis of previous data noticed that, different types of organic mulch and different LEDs light colors had a positive impact to improve all tested parameters i.e., (plant length, number of leaves/head, fresh and dry weights, N, P and K contents in leaves and total heads yield/m^2) among other treatments. The most favorable treatments for stimulating greatest values and heaviest productivity were noticed with compost mulch, LEDs "R + B + G" colors and their combination as compost mulch plus LEDs "R + B + G" colors treatments, in generally, overall, both tested seasons.

Compliance with ethical standards

Disclosure of conflict of interest

No Conflict of interest.

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