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Abstract

Light is essential for plants and algae as it enables them to produce food through photosynthesis, which supports their growth. However, there is currently a lack of research exploring the effects of different light colors on the growth of both plants and algae simultaneously. This study investigates the impact of various light colors on the growth of plants and algae by co-cultivating microalgae and lettuce in an indoor hydroponic system with four LED light colors: white, red, green, and blue. Each light color was tested in two experimental groups: one group with a hydroponic nutrient solution containing microalgae and another group without microalgae, across three cultivation cycles. The results showed that blue light was the most effective for microalgae growth, yielding a biomass of 0.517 g/L and a lipid content of 0.270 g/L, compared to other light colors across all cycles. Conversely, red light proved most effective for lettuce growth. Under red light, the number of leaves increased by 1.2 times, stem height by 1.2 times, root length by 1.2 times, fresh shoot weight by 1.6 times, dry shoot weight by 1.8 times, fresh root weight by 1.8 times, and dry root weight by 7.4 times, relative to other light colors. Overall, it can be concluded that blue light is optimal for microalgae growth, while red light is most suitable for lettuce growth in indoor hydroponic systems.

Introduction

Light is an essential factor for plants and algae, as they rely on it for growth. Light at different wavelengths affects the growth of plants and algae in various ways. For example, red light influences stem growth, leaf expansion, and even flowering, while blue light promotes root formation in the early stages of plant growth and affects chlorophyll content.

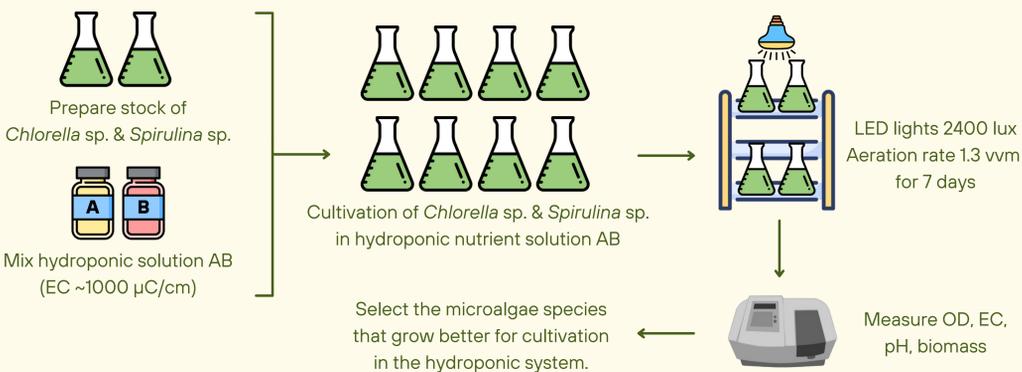
In indoor hydroponic system where microalgae are cultivated alongside lettuce, not only can lettuce be harvested, but biomass from the algae can also be obtained. This biomass can be used for biodiesel production and applied in the food industry.

Objectives

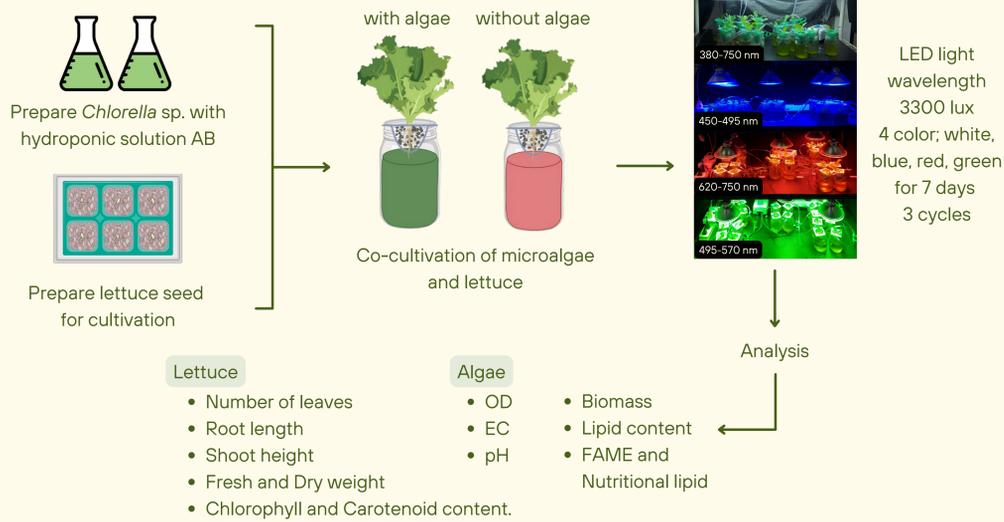
- To develop the co-cultivation of microalgae and lettuce in hydroponics system.
- To study the effect of light wavelengths on microalgae and plant growth in co-cultivation.

Methods

1. Cultivation of Microalgae in Hydroponic Nutrient Solution AB



2. Co-cultivation of Microalgae and Lettuce in Indoor Hydroponic System Under Different LED Light Wavelengths



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References

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Results

1. Cultivation of Microalgae in Hydroponic Nutrient Solution AB

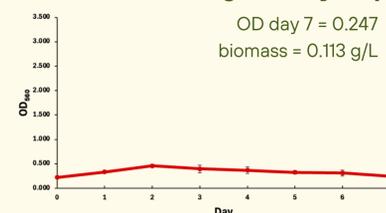


Figure 1. Growth of *Spirulina* sp. in hydroponic nutrient solution AB

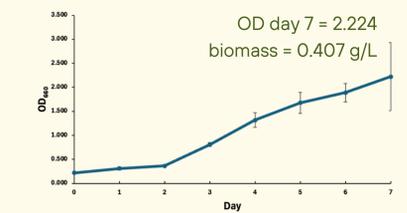


Figure 2. Growth of *Chlorella* sp. in hydroponic nutrient solution AB

2. Co-cultivation of Microalgae and Lettuce in Indoor Hydroponic System Under Different LED Light Wavelengths

Algae

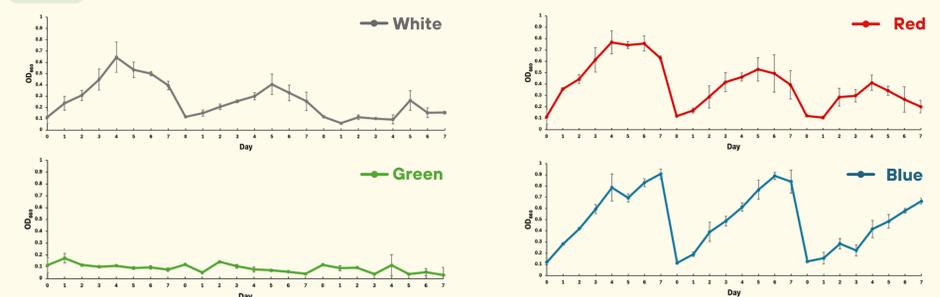


Figure 3. Growth of *Chlorella* sp. under different LED light wavelengths

Table 1. Biomass and lipid of *Chlorella* sp. under different LED light wavelengths

Biomass (g/L)	White	Red	Green	Blue
Cycle 1	0.079±0.00	0.160±0.02	0.034±0.00	0.176±0.02
Cycle 2	0.058±0.00	0.083±0.01	0.074±0.00	0.158±0.01
Cycle 3	0.066±0.01	0.089±0.01	0.084±0.01	0.183±0.01

Table 2. FAME of *Chlorella* sp. under different LED light wavelengths in cycle 3

Composition	White	Red	Green	Blue
C16-C18	95.83±0.02	96.37±0.01	96.51±0.03	96.58±0.02
Saturated	44.58±0.36	43.93±0.07	43.79±0.73	44.61±0.10
fatty acids (SFAs)				
Unsaturated	55.42±0.36	56.07±0.07	56.21±0.73	55.39±0.10
fatty acids (UFAs)				
Monounsaturated	1.67±0.03	2.17±0.02	1.78±0.02	1.81±0.02
fatty acids (MUFAs)				
Polyunsaturated fatty acids (PUFAs)	53.76±0.39	53.90±0.09	54.43±0.71	53.58±0.12

Table 3. Biodiesel of *Chlorella* sp. under different LED light wavelengths in cycle 3

Parameter	White	Red	Green	Blue	Biodiesel standards
SV	207.68±0.06	207.61±0.01	207.48±0.13	207.70±0.03	EN 14214 ASTM D6750 TH 2020
IV	120.68±0.53	116.19±0.60	119.41±1.79	115.74±0.19	≤120
CN	45.43±0.13	46.45±0.13	45.74±0.42	46.54±0.04	≤51
DU	110.22±0.51	110.08±0.17	110.51±1.45	109.02±0.21	NA
LCSP	5.78±0.24	6.14±0.01	6.14±0.55	6.21±0.00	NA
CPPP	1.67±0.75	2.82±0.03	2.88±1.73	3.02±0.01	≤0.5
HHV	39.11±0.01	39.18±0.03	39.18±0.00	39.18±0.00	NA
OS	4.74±0.01	4.73±0.00	4.74±0.01	4.73±0.00	≤5
CP	14.99±0.14	14.78±0.03	14.48±0.23	14.81±0.05	NA
V	6.69±0.00	6.69±0.00	6.69±0.00	6.69±0.00	3.5-5.0
p	0.97±0.00	0.97±0.00	0.97±0.00	0.97±0.00	0.86-0.90
API	109.45±0.54	108.87±0.19	109.87±1.45	107.75±0.11	NA
BAPE	76.77±0.34	71.86±0.57	75.17±1.22	71.95±0.11	NA

Table 4. Nutritional lipid of *Chlorella* sp. under different LED light wavelengths in cycle 3

Sources	Nutritional indices	PUFA/SFA	IA	IT	h/H	HPI	LI
Salmo trutta	NA	0.64-0.72	0.21-0.30	NA	NA	NA	NA
Milk of cow	0.02-0.04	1.85-5.13	2.23-4.66	0.41-0.57	NA	NA	NA
Chicken	0.308-2.042	0.17-0.63	0.29-1.69	NA	NA	NA	NA
Cattle	0.11-0.2	NA	NA	1.56-2.08	NA	NA	NA
Green seaweed	0.23-0.88	0.86-1.61	1.28-2.90	NA	NA	70.87-141.87	NA
Brown seaweed	0.20-1.38	0.53-1.99	0.46-1.60	1.26-1.90	NA	62.27-202.83	NA
Red seaweed	0.14-2.12	0.38-2.87	0.52-5.75	2.09-4.22	NA	50.63-257.07	NA
Rhopalodia sp. AARL D020	0.56	0.94	1.11	0.82	1.06	102.72	NA
Anomoeoneis sp. AARL D039	0.37	0.68	1.15	0.57	1.46	104.01	NA
Spirulina sp.	1.01	0.7	1.6	0.6	NA	NA	NA
Spirulina sp. BSF	0.278	1.128	2.261	0.442	0.886	59.737	NA
<i>Chlorella</i> sp.							
White	1.232	0.688	1.496	1.490	1.454	132.585	NA
Red	1.229	0.683	1.448	1.499	1.464	127.666	NA
Green	1.241	0.669	1.489	1.530	1.530	131.184	NA
Blue	1.202	0.695	1.526	1.482	1.438	127.177	NA

Lettuce

Table 5. Growth of lettuce under different LED light wavelengths in day 21

Parameter	With Algae				Without Algae			
	White	Red	Green	Blue	White	Red	Green	Blue
Number of leaves	9.10±0.23 ^a	11.30±0.34 ^a	9.40±0.45 ^b	11.30±0.73 ^a	9.20±0.25 ^b	12.20±0.73 ^a	9.40±0.27 ^b	11.70±0.37 ^a
Shoot length (cm)	14.05±0.24 ^a	14.70±1.11 ^a	11.70±0.50 ^b	14.32±0.40 ^a	14.85±0.40 ^a	15.70±0.40 ^a	14.85±0.62 ^a	14.50±0.48 ^a
Root length (cm)	13.05±2.22 ^a	14.00±1.61 ^{bc}	16.40±1.18 ^{bc}	15.70±0.30 ^{bc}	14.55±1.95 ^{bc}	20.60±1.45 ^a	18.60±1.07 ^{bc}	16.00±0.88 ^{bc}
Fresh weight (g)	5.85±0.46 ^b	12.49±1.37 ^a	9.45±0.72 ^{bc}	9.58±0.84 ^{bc}	6.89±0.45 ^b	13.14±3.23 ^a	8.87±1.37 ^{bc}	9.80±0.79 ^{bc}
Dry weight (g)	0.22±0.04 ^a	0.66±0.05 ^{bc}	0.56±0.21 ^{bc}	0.52±0.15 ^{bc}	0.39±0.01 ^{bc}	0.95±0.22 ^a	0.70±0.10 ^{bc}	0.58±0.02 ^{bc}
Chlorophyll a (mg/g)	0.31±0.01 ^{ab}	0.35±0.03 ^a	0.29±0.01 ^{ab}	0.32±0.04 ^{ab}	0.29±0.02 ^{ab}	0.23±0.05 ^b	0.30±0.01 ^{ab}	0.29±0.03 ^{ab}
Chlorophyll b (mg/g)	0.27±0.01 ^a	0.29±0.02 ^a	0.27±0.02 ^a	0.28±0.03 ^a	0.26±0.02 ^a	0.29±0.07 ^a	0.25±0.01 ^a	0.26±0.02 ^a
Total chlorophyll (mg/g)	0.58±0.01 ^a	0.64±0.05 ^a	0.56±0.03 ^a	0.60±0.07 ^a	0.55±0.04 ^a	0.52±0.06 ^a	0.55±0.02 ^a	0.55±0.05 ^a
Carotenoid (mg/g)	0.14±0.00 ^{ab}	0.17±0.01 ^a	0.14±0.01 ^{ab}	0.15±0.02 ^{ab}	0.12±0.01 ^b	0.12±0.01 ^b	0.15±0.01 ^{ab}	0.14±0.01 ^{ab}

Conclusion

- Chlorella* sp. is the preferred choice for co-cultivation with lettuce under different LED light wavelengths.
- Blue LED light promotes optimal microalgal growth.
- Red LED light is more effective for enhancing lettuce growth.
- Lipids derived from cultivated algae exhibit diverse profiles suitable for nutraceutical and biofuel applications.