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Evaluation of the Potential of PGPR on the Improvement of Flower Yield and Quality Under the Action of Photovoltaic Grow Lamp

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Abstract. However, there is controversy about the role and impact of PV growth on PGPR (Plant Growth-Promoting Rhizobacteria) in soil, so this paper uses regression analysis to study the effect of PV grow lights on PGPR and the improvement of flower yield and quality. The results showed that the PV grow lamp could simulate sunlight and stably output 455nm of light, which could improve the yield of flowers T1 (7.53%), quality T2 (15.40%) and potential T3 (30.28%), and the leaf length, plant height, plant protein and chlorophyll content were higher than those of normal growing plants. Therefore, solar photovoltaic grow lights can realize the conversion of sunlight, and expand the application range of photovoltaic power generation by converting them into analog wave frequencies through photovoltaic technology.

Key words. PV Grow Lights, PGPR, Flowers, Yield, Quality, Potential Evaluation.

1. Introduction

The purpose of the grow lamp is to promote the growth of flowers, stimulate the increase of chlorophyll, and promote the synthesis of plant protein, so as to prolong the growth time of plants. Therefore, photovoltaic production is widely used in the agricultural field. However, there are differences between PV grow lights and sunlight in terms of wavelength bands and energy forms, and there is controversy about whether they have an impact on probiotics in the soil and nutrient uptake by plant roots [1]. Some scholars believe that photovoltaic production lamps only stimulate the chlorophyll of flowers, which may kill the probiotics in the soil and affect the probiotic group of the soil [2], [3]. Some scholars believe that photovoltaic production lamps are the application of solar renewable energy, which can promote the growth of rhizomes and leaves, and promote the reproduction and formation of PGPR by simulating sunlight waves and bands, but there is a lack of practical cases [4]. Some scholars, under the condition of grow light lighting, found that a high proportion of blue light can significantly promote the growth of plant leaves and enhance its resistance to viruses, thereby effectively promoting the growth of plants and increasing their yield [5]. Some scholars also believe that mixed light is beneficial to the growth of plants, and its growth efficiency is higher than that of single light quality treatment [6], so there are doubts about the effectiveness of grow lights. At the same time, some scholars add red and blue light on the basis of white light, which can enhance the photosensitive effect of chlorophyll in leaves, thereby enhancing its photosynthesis, which is conducive to the accumulation of protein and sugar. Based on the above analysis, the effect of grow lights on plant growth is obvious, while there are relatively few studies on yield and quality. Based on this, from the perspective of photovoltaic grow lights, this paper takes PGPR as the research object, and the yield and quality of flowers as the research indicators are used for regression analysis [7], [8], and find out the factors that play a role in the long march of photovoltaic growth, such as band frequency, irradiation time and the influence on PGPR. Firstly, the test of photovoltaic production lamp was carried out, and the data of PGPR were observed and collected, and its quality and growth time were judged and analyzed, and then the yield and quality of flowers were tracked and measured, and finally the index relationship between photovoltaic grow lamp and natural light growth irradiation was compared, and the effect point of photovoltaic grow lamp and the overall impact on flower yield and quality were found, so as to provide support for agricultural planting and photovoltaic product research and development in the later stage.

2. Description of the Effect of Photovoltaic Grow Lights on the Yield and Quality of Flowers

A. Effect on PGPR in Soil

The regression model was used to approximate the simulation of soil acidity and alkalinity and probiotic population $\hat{F}$, and the output samples of PGPR were obtained through the input of band, intensity and time. Hypothesis 1: Mapping individual microbiota $x \in \mathbb{R}$ to soil microbiota within $y \in R$ a range. In order to adapt to the universality, the microflora is assumed to remain unchanged and is not constrained by other conditions, such as temperature, humidity, etc. [9], and the microbiota data are used to $D = [(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)]$ compare the changes between the microflora by using the minimization loss function $E_{\hat{F}}$, and finally the development results of the microbiota are obtained $\hat{F}$. In regression analysis, the mean square deviation function of the microflora can be used as its common loss function, which is calculated as shown in equation (1).

$$E_{\hat{F}} = \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \hat{F}(x_i)\right)^2 \quad (1)$$

In the above equation, D the sample size of the PGPR set is that n the reproduction degree of $x_i \in D$ the individual microbiota is y_i and the microbiota development function is $\hat{F}(x_i)$ Due to the multiplication and development process of microflora, there are also many struggles and evolution of different microflora, so it is necessary to constrain the microflora and solve the calculation cost of microbiota evolution.

B. Description of Flower Rhizome Growth

In the growth of flowers, there is a widespread problem of mismatch between growth and light. In this type of question, flower and vegetation growth should be described. Calculate the relationship between light time and protein and chlorophyll of plants and flowers, and also calculate the influence of the band and irradiation time of photovoltaic grow lights on chlorophyll. Measure the growth of the whole plant rhizomes and leaves [10], and find out the role indicators of photovoltaic grow lights. The rhizome is the main point of the action of the photovoltaic grow light, and it is also the key part of the role of the PGPR, so the growth of the rhizome should be measured. In order to accommodate universality, consider the rhizome capacity as N , the set of growth processes as $D=[(x_1,y_1),(x_2,y_2),\ldots,(x_n,y_n)]$, and the rhizome growth process, which can be represented by Eq. (2):

$$\hat{F}(x) = \sum_{j=1}^{p} w_j b_j(x) + \sum_{i=1}^{p} \lambda_i \phi\left(\|x - c_i\|\right) \quad (2)$$

The light growth part of rhizome in equation (2) is represented p by multivariate regression analysis, and the coefficient of the first i term of light time is λ_i , the first i growth degree is denoted by c_i , and the rhizome growth function is $\phi(\cdot)$. It c_i is a collection of natural growth during the growth of rhizomes. If all the rhizome growth samples in the PV grow light are included $\{c_i = x_i \in D | i = 1,2,\ldots,N\}$, the promotion value of the PV grow light is equal to the natural growth value, and the relationship between the two is:

$$\sum_{i=1}^{p} \lambda_i b_j(x_i) = 0 \quad (3)$$

Therefore, the relationship between the root growth and $\lambda = [\lambda_1, \lambda_2, \ldots, \lambda_m]^T$ stem growth in $w=[w_1,w_2,\ldots,w_p]^T$, Eq. (3) can be solved by Eq. (4).

$$\begin{bmatrix} \Phi & B \\ B^T & 0 \end{bmatrix}\begin{bmatrix} \lambda \\ w \end{bmatrix} = \begin{bmatrix} y \\ 0 \end{bmatrix} \quad (4)$$

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$$V_i = \left\{p_i \in S \middle| d(p, p_i) \le d(p, p_j), \forall j \ne i\right\} \quad (5)$$

The plant growth at p_i different time points and in Eq. (5), p_j is $d(p_i, p_j)$.

According to equation (5), it can be obtained: at any time, the amount of plant protein and chlorophyll is the largest, and the relationship between the two is the perpendicular line. The function of the photovoltaic grow light is to connect the connecting points of all flowers, and form a central point of yield and quality, and at the same time, define the optimal growth point and determine the efficiency and action point of the photovoltaic grow light. For the effect of photovoltaic grow lights, it is necessary to constrain them, respectively, the daytime growth data $F' = \{f_k | k = 1,2,\ldots,n\}$ set and the night growth data set $A' = \{A_j | j = 1,2,\ldots,m\}$, and the daytime growth is a mixture of photovoltaic grow lights and daylight, which can be recorded as $P(A_i \succ A_j)$ the approximate calculation of the yield and result of growth by equation (6).

$$P(A_i \succ A_j) = \frac{1}{n}\sum_{k=1}^{n} P(q_{i,k} < q_{i,k} | f_k) \quad (6)$$

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$$P\left(q_{i,k} < q_{i,k} \left| f_k \right.\right) = \frac{\sum_{s=1}^{s_i} \sum_{s=1}^{s_j} \mathbb{Z}\left(y_{i,k,s} < y_{i,k,t}\right)}{s_i \times s_j} \quad (7)$$

In Eq. (7) above, the optimal growth result is $y_{i,k,s}$ denoted by; A_i and A_j the number of acts in the cycle are expressed by s_i and s_j by the amount $\mathbb{Z}(\cdot)$ of its single growth.

3. Experimental Cases and Analysis

A. Materials, Treatment, and Design of Experiments

June~August 2022 was selected as the cycle, and lily flowers were selected as samples (yellow, blue and white), and the chlorophyll, protein and anthocyanin contents of lily flowers were observed by dyeing method and PCR method. The photovoltaic grow lamp is produced by Guangdong Technology Co., Ltd., with a wavelength band of 400~500nm and a light frequency of 50~80Hz. The bottom of the lily is padded with 2.5 cm× 2.5 cm × 2.5 cm sponge blocks, which are illuminated under different combinations of spectrum. In order to ensure the accuracy of the test, the PGPR nutrient solution was used as soil and hydroponic termination. At the same time, the pH in hydroponics is guaranteed to be 9.18, the relative humidity of the air is 70±5%, and the water temperature is also 24±2 degrees. The experimental environment is a four-story hydroponic facility, the ground floor is equipped with a water reservoir, and the remaining three floors are arranged with three PC pipes with planting holes. These pipes are interconnected with water pipes, pumps, and PC pipes to enable the circulation of water and nutrients at different levels, as shown in the specific hydroponic facility shown in Figure 1.

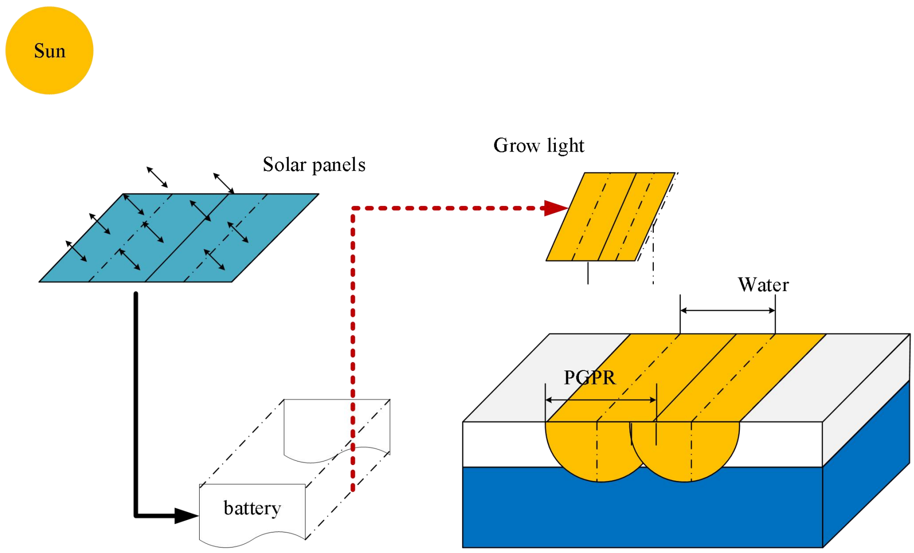


Fig. 1. The Action Process of Photovoltaic Grow Lights

In the experiment, natural light was selected as the control group (CK), and three different experimental treatment groups were set up. In this study, stem T1, leaf T2 and root T3 were taken as the research objects, and the role of photovoltaic grow lights was observed, the light energy was set to T1 (7.53%), T2 (15.40%) and T3 (30.28%), the light band was 455nm, and the emission frequency was 45~50Hz. The power supply of the photovoltaic grow lamp is a 10mm polycrystalline silicon transistor, the irradiation time is 24h, the battery is an Aluminum phosphate battery, the voltage is 12V, the current is 1.2A, and the results after illumination are shown in Table 1.

Table 1. Irradiation Parameters of Photovoltaic Grow Lights on Flowers

Constituencies	Energy/Micromol	PV Power/KJ	Grow Light Energy/KJ	Vegetable Protein/mg	Chlorophyll/mg
T1	52±0.56	1023	3.2	152	25
T2	55±0.21	1035	2.85	102	42
T3	45±0.16	998	3.06	45	10
F=0.254					

In addition, there is a stable correlation between PV grow lights and flower yield, as shown in Figure 2.

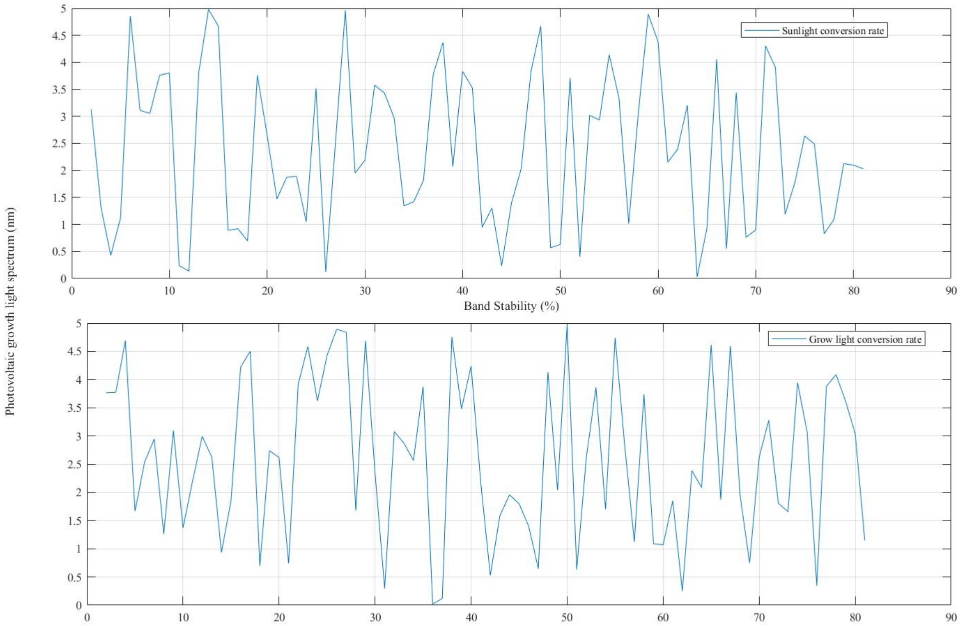


Fig. 2. Conversion Rate of Photovoltaic Grow Lights

As can be seen from Figure 2, the conversion rate of photovoltaic grow lights is basically the same, and the change between solar conversion and light conversion is almost the same.

B. Impact of Flower Production

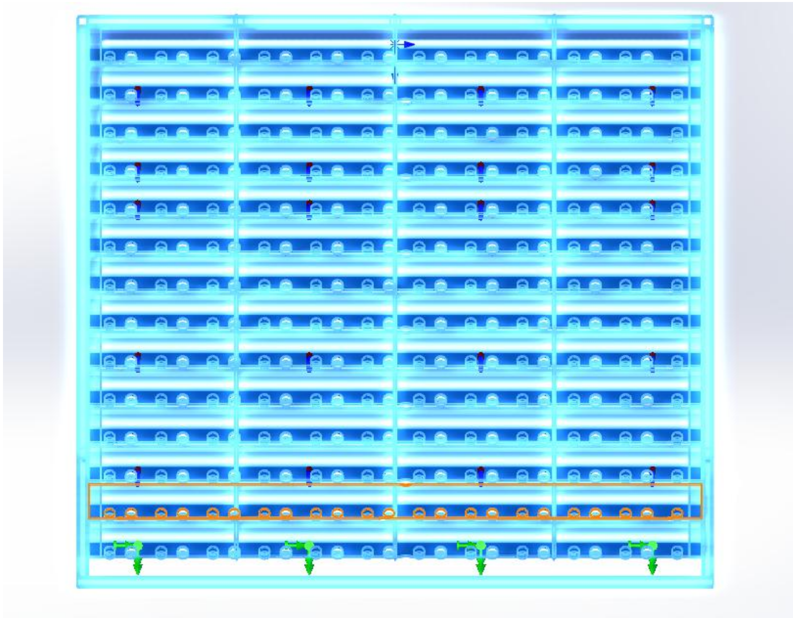
Set the photovoltaic working time to be on for 20 min and off for 20 min, a total of 6 photovoltaic generators, in order to reduce the error of the motors, the average value of all photovoltaic power generation data was selected for measurement. The height of flower leaves, rhizomes and rhizomes in each group was measured and recorded by PCR method, and the measurement accuracy was 01 mm.

However, when compared with the number of leaves and rhizomes of naturally growing flowers, the results are shown in Table 2.

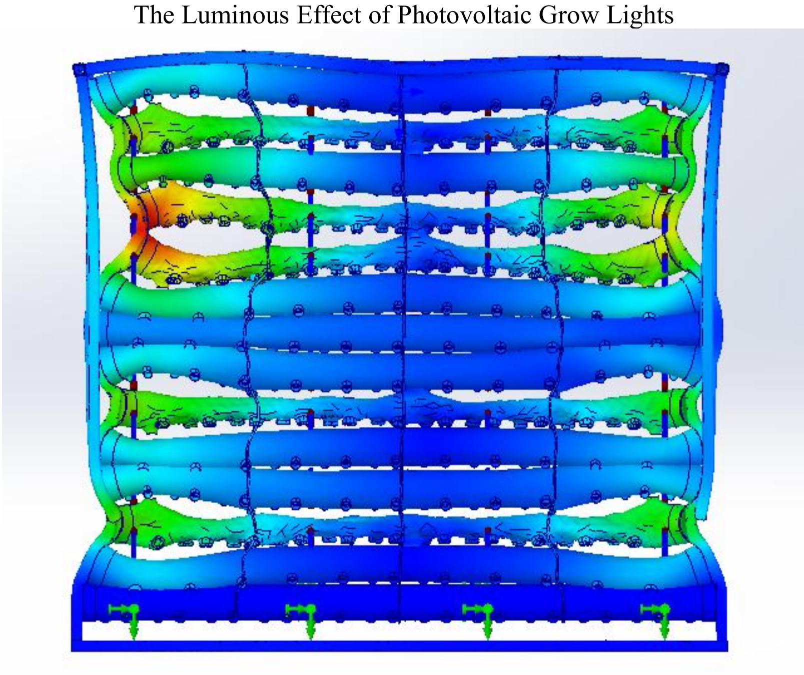
Table 2. Effect of Light on Flower Yield

Time	**Plant-Based Protein**			**Chlorophyll**		
	Grease (g)	Light Energy Conversion Rate%.	Cumulative %	Chlorophyll a or b （mg）	% Absorption of Light Waves	Photovoltaic Power Generation Cumulative Rate %
1~10d	1.315	32.880	32.880	1.315	32.880	32.880
10~20d	1.226	30.660	63.539	1.226	30.660	63.539
20~30D	0.818	20.438	83.977	-	-	-
30~40D	0.641	16.023	100.000	-	-	-

As can be seen from Table 2, chlorophyll a and chlorophyll b have the highest yields in the early stage and have the greatest absorption capacity in the wavelength range of 645 nm and 663 nm. The vegetable protein of flowers was extracted with distilled water, and then Coomassie Brilliant Blue G-250 was added for dyeing, and it was found that the dyed extract produced a higher plant protein at a wavelength of 595nm, about 1.226g, and the cumulative rate of photovoltaic power generation at this time was 63.539%, as shown in Figure 3.



The Luminous Effect of Photovoltaic Grow Lights



The Light Energy Effect of Photovoltaic Grow Lights

Fig.3. Effect of Photovoltaic Grow Lights

Through the test of photovoltaic grow lights, it was found that the chlorophyll content of flowers (including chlorophyll a and chlorophyll b) increased, but did not show a concentrated trend, indicating that photovoltaic grow lights can convert solar energy into visible light and stimulate the increase of chlorophyll. Studies have shown that chlorophyll a and chlorophyll b have the greatest absorption capacity in the wavelength range of 645 nm and 663 nm, and photovoltaic grow lights can effectively reproduce renewable energy and increase the absorption rate of chlorophyll a and chlorophyll b, as shown in Figure 4.

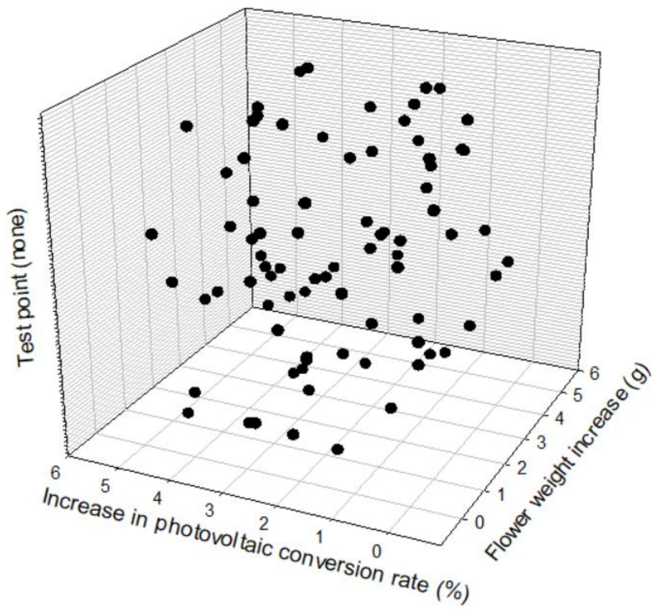


Fig. 4. Changes in Flower Yield Under Photovoltaic Grow Lights

As can be seen from Figure 4, there is a significant correlation between the yield of flower grow lights and the photovoltaic conversion rate. Moreover, the relationship between the two is independent of the test point, indicating that there is a significant correlation between the two samples in the case of arbitrary samples. Therefore, photovoltaic grow lights can increase the yield of flowers.

C. Improvement and Influence of Flower Quality

At a distance of 25 cm, the light source performance of the three groups of flowers was measured using a -200AW/BW LED optical spectrum analyzer, and the rhizome density of the flowers was found, as well as the overall weight increase. The light energy absorption of T1, T2 and T3 was 3.38 μmol/m2, 4.20 μmol/m2 and 5.70 μmol/m2. The density and weight of T1 are 12.46g/m3 and 27., respectively22g, the density and weight of T2 are 21.04g/m3, 23.03g, respectively. Among them, CK is a plant that grows in the natural environment, and its quality is 10~20% lower than that of T1, T2 and T3. This is mainly due to the long illumination time of the PV grow lights, the specific results are shown in Table 3.

Table 3. Light Source Performance Parameters of LED Light Source for Photovoltaic Grow Lights

Has	Power/μmol/m2	Length/m	Density g/m3	Weight/g
T1	18	12	1122.46	21.04
T2	18	12	2827.71	25.79
T3	18	12	3247.34	23.03
CK	-	-	-	-

In addition, there is a close correlation between flower quality and PGPR, so it is necessary to test the PGPR of photovoltaic grow lights and compare the PGPR under different groups. The results showed that the number of PGPRs in the T3 treatment was higher than that in the CK group, while there was no significant difference in the number of flowers in the other treatments. The PGPR clusters of T3 and T2 were significantly more than those of CK and T1, while the effect of T1 was slightly smaller. Comparing the amount of bacterial mass among the different groups, the number of T3 and T1 was significantly higher than that of CK and T2. However, there was no significant difference between T2 and CK (control group), and the specific results are shown in Table 4.

Table 4. Effect of PV Grow Lights on the Reproduction of PGPR (Mean ± Standard Deviation).

Dispose	Number of colonies/pcs	Quantity/10,000 units	Species of microbial group/pcs
T1	6.00±0.00b	7.53±0.36b	6.93±0.15b
T2	6.00±1.00b	8.20±0.30a	6.43±0.12bc
T3	6.67±0.57A	8.30±0.64a	7.86±0.17A
CK	5.67±1.15b	5.45±0.26c	6.16±0.12c

The colorimetric test showed that the number of PGPRs in T3 was greater than that in T1 >T2 >, which meant that the PGPR treated with T3 had better survival, indicating that the influence of high light energy and high frequency spectrum was significant. However, the role of photovoltaic grow lamps on PGPR is more significant, which can promote the development of PGPR, mainly because photovoltaic grow lamps improve the spectral range of ultraviolet rays, reduce their bands, and reduce the damage to PGPR. In addition, photovoltaic grow lights provide continuous light to maintain the temperature and humidity of the soil. Photovoltaic grow lights have a significant effect on the chlorophyll synthesis of flowers, promote the increase of total chlorophyll, chlorophyll a and chlorophyll b content, and can improve the living environment of PGPR, promote its reproduction and growth, and indirectly promote the production of chlorophyll, as shown in Table 5.

Table 5. Effect of PV Grow Lights on the Survival Conditions of PGPR (Mean ± Standard Deviation).

Dispose	Comprehensive conditions (%).	Temperature (%).	Humidity (%).	Light energy (%).
Bacillus	5.50±0.02c	3.71±0.01c	1.79±0.01b	2.06±0.01a
Pseudomonas	7.74±0.08b	4.63±0.01b	3.11±0.07a	1.48±0.03c
Azotobacte	8.43±0.01a	5.36±0.02A	3.07±0.03a	1.74±0.02b
Azotobacte +Azospirillum	4.79±0.08d	3.04±0.06d	1.72±0.03c	1.81±0.07b

The variation of the different PGPRs is shown in Figure 5.

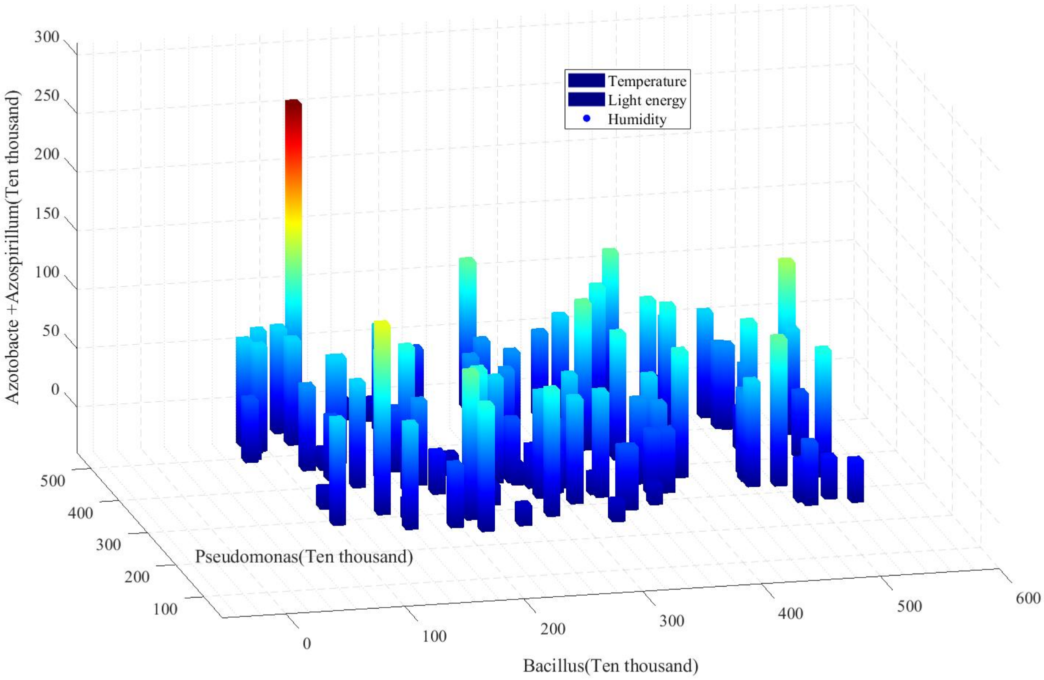


Fig. 5 Effect of photovoltaic grow lights on PGPR

As can be seen from Figure 5, the growth process of PGPR fluctuates and is relatively natural as a whole, indicating that the PV grow lamp has an obvious effect on PGPR and can promote its growth. In addition, PGPR received less UV damage from short-wave rays and could grow better, indicating that PV grow lights have a significant impact on the sustainability of PCGR.

4. Conclusion

Experiments have proved that the wavelength range of photovoltaic grow lights is in the range of 400~500nm, and the optimal wavelength is 455nm. Photovoltaic grow lights can promote the growth of flowers and plants, increase the density of plants, and increase the synthesis of plant protein, chlorophyll a and b. The sunlight conversion rate of photovoltaic grow lights is almost the same as the illumination rate, and it can reduce the generation rate of ultraviolet rays, promote the change of PGPR humidity, temperature and light intensity, and significantly promote the growth of flowers, with an increase rate of 5~10%. Photovoltaic grow lights have a significant effect on the stimulation of chlorophyll, which not only helps to speed up the weight and quality of flowers, but also helps to increase the amount of protein of plants and improve the growth environment of flowers. The use of photovoltaic grow lights can improve the effect of PGPR, achieve the purpose of improving the soil environment, and increase the growth rate of plants. Photovoltaic grow lights can improve the photoelectric conversion effect, promote plant production, energy saving, good safety, and reasonable spectral range. There are shortcomings in this study, mainly to analyze the photosynthesis mechanism of chlorophyll and photovoltaic cells, and ignore the role of photovoltaic grow lamps in carbohydrate content.

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