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Growth response and yield quality of broccoli microgreen (*Brassica oleracea* var. Italica Planck) to LEDs irradiance duration and types of nutrients

SHUNKEN CELESTINO, I NYOMAN RAI * and IDA AYU PUTRI DARMAWATI

Agroecotechnology Study Program, Faculty of Agriculture, Udayana University, Bali, Indonesia.

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Abstract

Microgreens are young plants harvested at the age of 7-21 days. Various edible plants can be cultivated into microgreen, one of which is broccoli. The purpose of this study was obtaining the appropriate irradiance duration and types of nutrients for broccoli microgreen growth. The research was conducted at Microgreen Farm, Sidakarya, Denpasar, Bali, Indonesia from January to February 2023. This experiment used split plot Randomized Block Design (RBD) consisting of 2 factors and 3 replications. The first factor was the irradiance duration consisting of 3 levels, namely L_1=14 hours/day, L_2=17 hours/day, L_3=20 hours/day. The second factor was the types of nutrients, namely: N_k=control/without nutrition, N_a=AB mix 1000 ppm, N_c=eggshells powder. The result revealed that the interaction between the irradiance duration and the types of nutrients had no significant effect on the growth and yield quality of broccoli microgreen. L_1 gave the highest results on the length of the microgreen stem (7.19 cm) or an increase of 19% and significantly different from the lowest results obtained at the irradiance duration of 20 hours/day (6.04 cm). The N_a treatment significantly increased growth and yield quality components as indicated by variables of microgreen fresh weight per container (10,75 g), microgreen fresh weight per plant (106,09 mg), microgreen stem length (8,25 cm), percentage of harvested plants (46,90%), color (3,67), and crispness (3,37) compared to N_k which were 4,32 g, 49,55 mg, 5,23 cm, 40,55%, 3,24, 2,73, respectively.

Keywords: Broccoli; Microgreen; Irradiation; Nutrients

1. Introduction

There are various species of vegetables suitable to be cultivated in Indonesia, but the amount of daily consumption in Indonesia remains fairly low. Indonesian population on average consumes about 108.8 g/person/day of vegetables and fruits [1]. Meanwhile, WHO recommends the consumption of vegetables and fruits as much as 400 g/person/day. Vegetables and fruits contain vitamins, minerals and fibre needed to maintain the health of the body so it should be eaten in sufficient quantities.

Currently, there is a new trend in vegetable consumption known as microgreens. Microgreens are young plants harvested at 7-21 days after sowing when cotyledon leaves developed fully. Microgreens are popular because of its higher nutritional content compared to mature vegetables, making it a great source of nutrition for health.Various types of edible plants can be cultivated as microgreen, such as broccoli from the Brassicaceae family which is known to have abundant vitamins and minerals content.

Microgreen cultivation requires an understanding of the factors that affect plant growth such as light and types of nutrients. Light intensity, duration of irradiation and light quality are important aspects that affect the rate of photosynthesis in plants [2]. Research revealed that longer duration of irradiation can significantly increase biomass

* Corresponding author: I NYOMAN RAI

production in setaria plants [3]. However, different species of plants may respond differently to the length of irradiation. Therefore, further studies of the effect of irradiation duration on each species are necessary.

External nutrients provide the necessary elements required for plant growth. AB mix is widely used in microgreens cultivation because of its rich nutrients content. However, organic materials such as eggshells have also been chosen as alternative nutrients. Eggshells have a high calcium content. Various aspects of plant growth such as the formation of root hairs, plant stems, and seed formation are influenced by calcium [4].

Based on this description, it is necessary to conduct research to determine the best irradiance duration and type of nutrients to improve growth and yield quality in broccoli microgreen.

2. Material and methods

The research was conducted from January to February 2023 at the microgreen farm in Sidakarya Village, Denpasar, Bali, Indonesia. The experiment applied a split plot randomized block design (RBD) with 2 factors and 3 replications. The main plot factor was the irradiation duration consisting of 3 levels, namely 14 hours/day (L_1), 17 hours/day (L_2), 20 hours/day(L_3). The second factor was the types of nutrients, namely without nutrients (N_k), AB mix 1000 ppm (N_a), eggshells powder (N_c). Thus, 9 treatment combinations were repeated 3 times so that there were 27 experimental units. The LED lights were installed 20 cm from the plants.

The materials used in this study were broccoli seeds, chicken eggshells, pitmos, cocopeat, AB mix nutrients, tissue, distilled water, amylum, filter paper, labels, plastic bottles and iodine. The tools used include pots with a diameter of 10 cm, microgreen shelves, Barrina full spectrum LED lights, leaf color charts, pliers, cutters, measuring cups, syringes, rulers, scales, spoons, stationery, pipettes, plastic bags, mobile phone cameras, baskets, 1 ml pipettes, heating pans, mashing tools, funnels, and beakers.

Eggshells were cleaned and then dried in the oven. Afterwards, the eggshells are crushed to fine powder using a blender. AB mix solution was made according to the package instruction.

Seeds were prepared as much as 0.7 grams per pot/container and then spread in pots containing moistened planting media. Then sprayed the seeds with water. Next, wrap the pots with plastic wrap to prevent evaporation and then leave it in dark conditions for two days.

AB mix was applied twice a day on the planting media of the experimental units according to the nutrient treatments. Watering was done as needed. Broccoli microgreen was harvested 13 days after planting when the cotyledon leaves had fully developed.

The observation variables included the day the cotyledons emerged to the surface, colour changes, percentage of harvested plants, percentage of dead plants, stem length, fresh weight per container (stem and cotyledons), fresh weight per plant (stem and cotyledons), vitamin C content, and organoleptic test (colour, taste, aroma, crispness, and favorability level). Observation data were analyzed using analysis of variance (Anova). Single factors were further tested using LSD at the 5% level.

3. Results and discussion

The interaction between the duration of LED irradiation and the types of nutrients had no significant effect on the growth and yield quality of broccoli microgreen in all variables observed. In the single factor, the duration of irradiation had a significant effect on stem length while the types of nutrients had a significant effect on fresh weight per container, fresh weight per plant, stem length, percentage of harvested plants, colour and crispness. The mean values of the observation variables can be seen in Tables 1 to 3.

The longest microgreen stem was obtained in the treatment of 14 hours/day irradiation duration (L_1) which is 7,19 cm or tended to be higher by 19,03% than the lowest stem length obtained at 20 hours/day irradiation duration (L_3) which is 6,04 cm. These results indicated that longer irradiation will inhibit stem elongation. This was supported by the fastest cotyledon days to emerge found at the L_1 level (4,22 days). The shorter the time required for the cotyledons to emerge to the surface, the longer the microgreen stems will be. This was supported by the negative correlation value (r = -0,89**) between stem length and days cotyledons emerged. Plants exposed to light will experience a decrease in gibberellin content (hormone that promote stem elongation) due to inhibition of the expression of genes encoding

enzymes that have vital roles in gibberellin biosynthesis, while stimulating expression of genes encoding enzymes that reduce gibberellin content [5-7]. This would inhibit stem elongation. This was in accordance with research which stated that increasing the duration of irradiation induced kale microgreen to grow with shorter stems and wider cotyledons [8].

The highest fresh weight per container was obtained in the treatment of 20 hours/day irradiation duration (L_3) which was 7,49 g or tended to be higher by 8,23% than the lowest fresh weight obtained at 14 hours/day irradiation duration (L_1), which was 6,92 g. The increase of economic fresh weight per container at 20 hours/day irradiation (L_3) was supported by the percentage of harvested plants (44,85%), and the fresh weight of microgreen per plant (76.39 mg) which also showed the highest results at L_3. These results were supported by the positive correlation value between the fresh weight per container with the fresh weight per plant (r=0,99**) and the percentage of harvested plants (r= 0,90**). Longer duration of irradiation increase the rate of photosynthesis which help plants produce more energy and assimilates needed to form tissues and organs that will affect the biomass of the broccoli microgreen. However, this study showed that the irradiance duration of 20 hours (L_3) had not been able to provide results significantly different from L_1. This occured because the plants have received enough light so the fresh weight did not experience a significant increase. Research showed that irradiance duration of 14-16 hours/day was sufficient for the cultivation of cabbage and chinese kale microgreen [9].

Table 1 Effect of Irradiance Duration and Types of Nutrients on Average Days of Cotyledons to Surface, Colour Change, Fresh Weight per Container, Fresh Weight per Plant

Treatment	Days of Cotyledons to Surface	Colour Change	Fresh Weight per Container (g)	Fresh Weight per Plant (mg)
Irradiance Duration				
L_1	4,22 a	2,67 a	6,92 a	73, 39 a
L_2	4,33 a	2,72 a	7,22 a	74,50 a
L_3	4,67 a	2,88 a	7,49 a	76,39 a
LSD 5%	0,90	0,22	0,67	7,88
Types of Nutrients				
N_k	4,67 a	2,68 a	4,32 c	49,55 c
N_a	4,11 a	2,85 a	10,75 a	106,09 a
N_c	4,44 a	2,77 a	6,57 b	68,65 b
LSD 5%	0,58	0,18	0,88	11,74

Numbers followed by the same letter in the same treatment and column showed no significant difference in the 5% LSD test.

The longest stem was obtained at the N_a (AB mix 1000 ppm) treatment level of 8.25 cm or tended to be higher by 57,74% and was significantly different from the N_k (control) level of 5.23 cm. This result was supported by the days of cotyledons emerged to the surface at N_a which was 4.11 days. Research showed that AB mix treatment at concentration of 650-1300 ppm positively increase lettuce's height until the fourth week after planting [10]. AB mix nutrition contains complete nutrients needed by plants. The increase in plant height occured due to the event of cell division and extension which was dominated in the shoots where the nutrients absorbed by the plant will activate the meristem cells [11]. The length of broccoli microgreen stems at the eggshell flour treatment (N_c) was 6.09 cm or tended to be higher by 16,7% compared to N_k . The high calcium content in eggshells can activate root formation and strengthen stems [12]. The application of AB mix and eggshells powder fulfilled the nutritional requirements to encourage the growth of microgreen stems.

Table 2 Effect of Irradiance Duration and Types of Nutrients on Average Stem Length, Percentage of Harvested Plants, Percentage of Dead Plants, Vitamin C Content

Treatment	Stem Length (cm)	Percentage of Plants Grown	Persentage of Dead Plants	Vitamin C Content (mg/100g)*
Irradiance Duration				
L_1	7,19 a	42,75 a	57,24 a	16,43
L_2	6,35 b	44,13 a	55,86 a	18,07
L_3	6,04 b	44,85 a	55,14 a	19,24
LSD 5%	0,18	4,33	4,33	-
Types of Nutrients				
N_k	5,23 c	40,55 b	59,45 a	8,92
N_a	8.25 a	46,90 a	53,10 b	24,64
N_c	6,09 b	44,29 ab	55,71 ab	20,18
LSD 5%	0,61	4,30	4,30	-

*Vitamin C content was not statistically analysed, only lab tested per sample.

Table 3 Effect of Irradiance Duration and Types of Nutrients on Average Score of Colour, Aroma, Taste, Crispness, Favourability

Treatment	Colour	Aroma	Crispness	Taste	Favourability
Irradiance Duration					
L1	3,33 a	2,86 a	3,05 a	2,90 a	2,84 a
L2	3,38 a	2,89 a	3,15 a	2,92 a	2,87 a
L3	3,53 a	3,09 a	3,24 a	2,92 a	2,97 a
LSD 5%	0,39	0,28	0,25	0,12	0,18
Types of Nutrients					
Nk	3,24 b	2,81 a	2,73 b	2,78 a	2,77 a
Na	3,67 a	3,11 a	3,37 a	3,10 a	3,02 a
Nc	3,35 b	2,92 a	3,34 a	2,85 a	2,88 a
LSD 5%	0,23	0,31	0,36	1,00	0,34

1 = extremely dislike, 2 = slightly dislike, 3 = neutral/ neither dislike or like, 4 = slightly like, 5 = extremely like

The provision of nutrients had a significant effect on the fresh weight of broccoli microgreen per container. The highest fresh weight was obtained in the N_a treatment which was 10.75 grams or tended to be higher by 148,84% and significantly different from the lowest fresh weight per container obtained in the control treatment which was 4.32 grams. The fresh weight per container was influenced by the fresh weight per plant (106.09 mg), and the percentage of harvested plants (46.90%). The fresh weight per container in the eggshell powder treatment tended to be higher by 52.08% and significantly different from the control. These results were supported by the positive correlation value between the fresh weight per container with the fresh weight of microgreen per plant (r = 0.99**) and the percentage of harvested plants (r = 0.90**). Nutrients in AB mix nutrition and eggshells powder increase plant growth and immunity. Nitrogen (N) absorbed by plants was used to stimulate the vegetative growth of plants, such as leaves, stems and roots. The water content and nutrients absorbed by plants affect the number of leaves, leaf area, plant height, and

the development and growth of other plant tissues which will affect the fresh weight of the plant [13]. Calcium (Ca) acted as a signal carrier in plant cells. Ca^{2+} binding proteins such as calmodulin, calcium-dependent protein kinases and calcineurin B will translate Ca^{2+} signals to activate specific plant defence mechanisms against pathogens attack [14]. The higher percentage of harvested plants and fresh weight per plant indicated that the water and nutrients were available in sufficient quantities which increased the fresh weight per container of broccoli microgreen.

The highest level of favourability was obtained in the AB mix treatment (N_a) which was 3.02 (neutral) or tended to be higher by 9.02% but not significantly different from the level of favourability obtained in the control treatment (N_k) which was 2.77 (neutral). This was supported by the high score of crispness (3.34) and colour of broccoli microgreen (3.67) at the N_a level. Magnesium (Mg) contained in AB mix and eggshells powder played an important role in the formation of chlorophyll which gives a healthy green colour that made the microgreen looked more attractive. The potassium (K) content in AB mix and eggshell powder also increase the crispness of microgreen. Potassium can increase the synthesis and translocation of carbohydrates, thereby increasing the thickness of cell walls and stem strength [15]. These results were also supported by the positive correlation value between the level of favourability with crispness (r=0.73*), and colour (r=0.81**).

The highest vitamin C content was obtained in the treatment of 20 hours/day irradiation duration (L_3) and AB mix nutrition (N_a). This occurred due to an increase in the rate of photosynthesis due to the longer duration of irradiation and the availability of nutrients needed by microgreen broccoli through the provision of AB mix. Photosynthesis increased the amount of soluble carbohydrates which is a precursor to vitamin C biosynthesis in plants [16].

4. Conclusion

The duration of irradiation had a significant effect on the length of broccoli microgreen stems with 14 hours/day of irradiation gave the highest result of 7.19 cm. However, the duration of irradiation had no significant effect on the other variables observed. AB mix 1000 ppm significantly increased the fresh weight per container, fresh weight per plant, stem length, percentage of harvested plants, colour and crispness. The application of eggshell powder could not provide results as good as AB mix nutrition in all variables. The interaction between the duration of irradiation and the type of nutrition had no significant effect on the growth and yield quality of broccoli microgreen. Based on the results of the study, it is recommended to use an irradiation duration of 20 hours/day and 1000 ppm AB mix nutrition to increase the growth and yield quality of broccoli microgreen.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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