Effect of light intensity on the growth and production of rodent tuber (*Thyponium flageliforme* (Lodd.) Bl.)

R Suryadi, R A Permadi, E R Pribadi, O Trisilawati, I Darwati

Indonesian Spices and Medicinal Crops Research Institute (ISMCRI), Jl. Tentara Pelajar No. 3, Bogor 16111, West Java, Indonesia

Corresponding author email: rudisuryadi69@yahoo.com

Abstract. Rodent tuber is a wild plant that has the potential as an anticancer drug. For this purpose, the availability of materials is necessary, it needs good cultivation to maintain its herbal quality, and light intensity is one of its components. Therefore, research is needed to obtain light intensity that can increase the growth and production of rodent tuber plants. Shading research on rodent plants was carried out in a screen house, ISMCRI, from January to December 2020. The study was arranged in randomized block design, five treatments, and 40 samples per treatment with five replications. The treatment that were given is several levels of light intensity: 100%, 65%, 50%, 35%, and 25%. The number of leaves, chlorophyll content, fresh and dry biomass, fresh and dry weight tubers, nutrient content and nutrient uptake, protein content, and protein production are the parameters. The result showed light intensity significantly affected the number of leaves, fresh and dry weight tubers at eight months after planting. Plants that received 100% light intensity produced the highest growth and production of rodent tubers, while the lowest was 25% light intensity.

1. Introduction

Rodent tuber (*Thyponium flageliforme* (Lodd.) Bl.) has the potential as an anticancer medicinal plant [1,2]. The compounds contained in Rodent tuber are alkaloids, triterpenoids and lignans (polyphenols) [3], flavonoids, phenols, saponins, and sterols/triterpenoids [4]. Extraction with dichloromethane solvent obtained the active ingredients in the form of hexadecanoic acid, 1-hexadecene, phytol, phytol derivatives, linoleic acid, and 9-hexadecanoic acid [5,6], which can inhibit tumor cell proliferation [7], and is able to induce apoptosis. The biomolecular mechanism of *T. flageliforme* dichloromethanolic fraction in inhibiting proliferation and inducing apoptosis is unknown, especially in breast cancer cells [8]. Until now, the raw material for rodent tuber is generally still obtained from nature. This situation affects the availability of raw materials in the long term so that cultivation technology is needed to support the availability of raw materials if this plant is to be developed as a phytopharmaca.

Light is needed by plants to form energy and plays an essential role in plant physiological processes. Light is one of the most critical environmental factors in agricultural production [9]. Light acts as an activator of photosynthesis, which is the basis of plant growth and yield formation, affecting the photosynthetic apparatus’s structure and function [10]. Photosynthesis in cropping systems is often limited by light because of the mutual shading of intra- or inter-species plants. Generally, leaves grown under shade had higher chloroplast thylakoid stacks but lower chlorophyll content, Chl a/b ratio, and net photosynthetic rate than leaves that had developed under normal light conditions [11]. In addition, leaves under shade had lower content of electron transfer carrier and ribulose-1, 5-bisphosphate carboxylase/
oxygenase than those under normal light conditions [10]. Therefore, shading decreases the photosynthetic capacity of leaves during plant growth and development. Optimal light intensity will positively affect the photosynthesis process, which will result in high productivity. This study aims to obtain the light intensity level that increases the growth and production of Rodent tuber plants.

2. Material and methods
The research was conducted from January to December 2020 at the Screen house, ISMCRI Bogor, West Java. The experiment was arranged in a randomized block design with five treatments and five replications. The single treatment of light intensity level was tested at 100 %, 65 %, 50%, 35%, and 25%. The number of leaves, chlorophyll content, fresh and dry biomass, fresh and dry weight tubers, nutrient content and nutrient uptake, protein content, and protein production was observed.

The experiment used a mixture of soil and cow manure in a ratio of (2:1) v/v, which had previously been air-dried and sieved. According to the treatment, the media was put into polybags 15 cm x 20 cm and watered until saturated and arranged under screen house paranel with the incoming light intensity. The tubers of Rodent tuber used were whole tubers weighing between 0.96 g to 1.06 g. Before planting in polybags, the tubers are soaked with fungicide and sown for one week until the bulbs sprout. Rodent tubers were planted at a depth of 2 cm with the shoot position at the top. Maintenance carried out is watering once a day, weed and pest control is done manually.

Leaf chlorophyll content was measured using the spectrophotometric method [12]. The protein content of tubers used the titrimetric method [13]. Nutrient analysis of leaf nitrogen using the Kjeldahl method [14], phosphorus using the Spectrophotometric method [15], and potassium using the Atomic spectrophotometer method [16]. The data were analyzed using ANOVA and tested further with Duncan multiple range tests (DMRT) at 5% level.

3. Result and discussion
3.1. Number of leaves

| Treatments | Light intensity (%) | Age after planting (month) |        |        |        |
|------------|---------------------|----------------------------|--------|--------|--------|
|            |                     | 2  | 4      | 6      | 8      |
| 100        |                     | 8.59 a | 10.18 a | 11.19 a | 5.99 a |
| 65         |                     | 5.50 b | 6.98 b | 7.35 b | 3.93 b |
| 50         |                     | 6.07 b | 6.20 b | 3.93 c | 3.02 bc |
| 35         |                     | 5.46 b | 5.97 b | 3.85 c | 2.80 bc |
| 25         |                     | 5.26 b | 3.21 b | 3.53 c | 1.74 c |
| CV (%)     |                     | 13.10 | 16.22 | 21.48 | 17.63 |

Numbers followed by the same letter in the same column were not significantly at DMRT 15%.

The light intensity treatment showed a significant difference in the number of leaves from 2 months to 8 months (Table 1). The number of leaves increased from the age of 2 months to 6 months but decreased at eight months because the leaves at the bottom have fallen due to senescence. The lower the light intensity received by the plant, the smaller the number of leaves. The highest number of leaves was produced from plants that received 100% light intensity (46,000 lux), then 65% (29,000 lux), 50% (27,000 lux), 35% (24,000 lux) and the lowest was produced at 25% light intensity (1,500 lux) respectively. Light is one of the components in the process of photosynthesis. The largest number of leaves per plant was observed at full sunlight. The number of leaves/plant then decreased as the plants
were shaded up to 50% and 75% shade of Common Sage (*Salvia officinalis* L.) [17, 18] and Rodent tuber (*Thyponium flageliforme* (Lodd.) Bl.) [19].

3.2. Chlorophyll

The light intensity treatment was not significantly different from the content of chlorophyll a, chlorophyll b, and total chlorophyll (Figure 1). The higher the light intensity, the lower the chlorophyll a, b and total chlorophyll content. The content of chlorophyll a is more heightened than chlorophyll b. The content of chlorophyll at 25% light intensity (0.131%) is the highest and the lowest at 100% light intensity, as well as the highest chlorophyll b content at 25% light intensity (0.025%) and the lowest at 100% light intensity (0.020%). The highest chlorophyll a/b ratio was at 25% light intensity (5.227), while the lowest was at 100% (4.567). The ratio of chlorophyll a/b was produced at a lower light intensity in *Euglena gracilis* plants [20]. Low light intensity will increase the content of chlorophyll b. The increase in chlorophyll b is an attempt by plants to expand the antenna size on LHC II to achieve high efficiency in capturing light radiation [21]. Chlorophyll is a green color or pigment whose job is to absorb light and provide energy for photosynthesis. Chlorophyll a can absorb light spectrum effectively at wavelengths of 429 nm and 659 nm. The most important pigment in the process of photosynthesis is chlorophyll a. The function of chlorophyll a is as the primary electron donor in the photosynthetic electron transport chain.

Meanwhile, chlorophyll b is responsible for collecting light and forwarded to chlorophyll a for photosynthesis. Chlorophyll b is very effective in absorbing the light spectrum with wavelengths of 455 nm (violet) and 652 nm (red). Total chlorophyll tends to increase with lower light intensity. The content of chlorophyll a, b, and total in the leaves of *Hoya diversifolia* Bl. increases with decreasing light intensity [22].

![Figure 1](image-url) **Figure 1.** Chlorophyll a and b content, total chlorophyll, ratio chlorophyll a/b under different light intensity levels.

3.3. Biomass

Biomass is a term used to describe all organic materials produced from photosynthesis [23]. The highest part of the Rodent tuber plant in fresh and dry weight were tubers, leaves, and the lowest was roots (Figure 2 and 3). The highest biomass was produced from plants that received 100% light intensity, while the lowest was 25%. The Rodent tuber plant requires the full light intensity to optimize photosynthesis and increase growth and tuber production. In line with the research results from Sui and Harvey (2021), biomass production increases with increasing light intensity received by *Dunaeliella salina* plants [24].
Figure 2. Fresh weight of leaves (a), tuber (b), root (c) and total biomass (d) under different light intensity levels.

Figure 3. Dry weight of leaves (a), tuber (b), root (c) and total biomass (d) under different light intensity levels.
3.4. **Nutrient content and nutrient uptake**

The light intensity treatment did not significantly affect the nutrient content and uptake of N, P, and K. The light intensity also affected the nutrient content and uptake of N, P, and K in Lettuce plants [25]. The nutrient content in the leaves shows the difference between Nitrogen, Phosphorus, and Potassium. Potassium was the highest nutrient at 4.80%-6.39%, then Nitrogen was 2.39%-4.03%, and the lowest was Phosphorus 0.48%-0.99% (Figure 4). The ratio of Nitrogen to potassium is 1:2. Potassium is required in large amounts for optimal plant growth and productivity, as it is essential for completing various physiological and metabolic functions in plants [26]. Potassium is a macronutrient for overall plant growth, yield potential, product quality, and plant resistance to stress. Potato plants (*Solanum tuberosum* L.) that produce tubers require large amounts of potassium to achieve excellent yields and quality [27, 28, 29].

![Figure 4. Nutrient content and nutrient uptake under different light intensity levels.](image)

3.5. **Tuber production**

**Table 2.** Monthly changes in fresh and dry weights tuber under different light intensity levels.

| Treatments Light intensity (%) | 4 Age after planting (month) | 6 | 8 |
|-------------------------------|-----------------------------|---|---|
|                               | Fresh | Dry | Fresh | Dry | Fresh | Dry |
| 100                           | 8.02 a | 3.06 a | 11.97 a | 4.22 a | 12.46 a | 5.67 a |
| 65                            | 6.38 b | 1.70 b | 10.43 a | 2.66 b | 11.23 a | 5.46 a |
| 50                            | 6.17 b | 1.69 b | 8.67 b | 2.43 bc | 7.47 a | 2.78 b |
| 35                            | 6.20 b | 1.64 b | 6.35 b | 1.24 cd | 7.14 b | 2.48 b |
| 25                            | 3.68 c | 0.74 b | 3.72 c | 0.97 d | 4.28 c | 1.06 b |
| CV (%)                        | 12.83 | 16.65 | 15.21 | 18.35 | 11.90 | 10.03 |

Numbers followed by the same letter in the same column were not significantly at DMRT 15%.

The light intensity treatment had no significant effect on the fresh and dry weight of tubers at 2 months but had a significant impact at 4, 6, and 8 months after planting (Table 2). Plants that received 100% light intensity produced the highest fresh and dry weight of tubers (12.46 g; 5.67 g). 65% light intensity (11.23 g;5.46 g), 50% light intensity (7.47 g; 2.78 g), 35% light intensity (7.14 g; 2.48 g), and the lowest was obtained from the light intensity of 25% (4.28 g; 1.06 g). Treatment of light intensity also affects the water content of tubers. At 100% light intensity, the water content of the tubers was the lowest (54.49%), the light intensity was 65% (51.38%), the light intensity was 50% (62.78%), the light intensity
was 35% (65.27%). The highest water content was at the light intensity of 25% (75.23%). This result shows that plants that get full light intensity can store starch in larger tubers than plants that get shade. The provision of 50% shading on potato plants affected the starch content even though it had no significant effect compared to no shade. Shade 50% reduced tuber number and tuber weight by about 53% and 69% [30]. The growth and production of *Dioscorea esculenta* were better with no shade and decreased with 25% and 50% shade [31].

3.6. Total protein content and protein production

Light intensity treatment had no significant effect on total protein content and protein tuber production (Figure 5). One of the bioactives for anticancer in the Genus *Typhonium* is lectin. Lectin is a bioactive plant protein that shows antiproliferative activity. So there is a relationship between the total protein content and lectins in tubers of rodent tuber [2]. The treatment of 100% light intensity resulted in the highest total protein content and protein production (20.60% ; 116.80 g), followed by 65% light intensity (17.37%; 94.86 g), 50% light intensity (17.40%; 48.38 g), 35% light intensity. (16.43% ; 40.74 g), and the lowest light intensity 25% (15.76%; 16.71 g). Shade 50% reduced protein content to 3.5% in soybean plants [32].

![Figure 5. Total protein content and protein production under different light intensity levels.](image)

4. Conclusion

The light intensity of 100% has a better effect on all experimental parameters. Rodent tuber plants that received light intensity of 50%, 35%, and 25% produced lower fresh and dry weight of tubers. Meanwhile, light intensity at 100% and 65% produced the highest fresh and dry tuber weight. Therefore, it is recommended that Rodent tuber be cultivated in locations with whole light or tolerance up to 65% light intensity.

Acknowledgements

We would like to thank M. Zainudin and Teguh Santoso as a technicians for helping to research.

References

[1] Lai C S, Mas R H M H, Nair N K, Mansor S M and Navaratnam V 2010 Chemical constituents and in vitro anticancer activity of *Typhonium flagelliforme* (Araceae) *J. Ethnopharmacol.* 127 486–94

[2] Alfarabi M, Rosmalawati S and Bintang M 2015 Antiproliferation activity of tuber protein from *Typhonium flagelliforme* (Lodd.) blume on MCF-7 cell line *Int. J. Biosci.* 6 52–60

[3] Chodidjah, Widayati E and Nasiun T 2017 Treatment of *Typhonium flagelliforme* in combination with *Curcuma zedoaria* and *Phyllanthus niruri* synergistically enhances apoptotic and anti proliferative effect on breast cancer *J. Nat. Remedies* 17 1–8
[4] Mohan S, Bustamam A, Ibrahim S, Al-Zubairi A S, Aspollah M, Abdullah R and Elhassan M M 2011 In vitro ultramorphological assessment of apoptosis on CEMss induced by linoleic acid rich fraction from *Typhonium flagelliforme* tuber *Evidence-based Complement. Altern. Med.* 2011

[5] Mohan S, Abdul A B, Wahab S I A and Al-Zubairi A S 2008 Antibacterial and antioxidant activities of *Typhonium flagelliforme* (Lodd.) Blume Tuber *Am. J. Biochem. Biotechnol.* 4 402–7

[6] Singh M, Kumar D, Sharma D and Singh G 2013 Typhonium Flagelliforme: a Multipurpose plant *Int. Res. J. Pharm.* 4 45–8

[7] Korinek M, Tsai Y H, El-Shazly M, Lai K H, Backlund A, Wu S F, Lai W C, Wu T Y, Chen S L, Wu Y C, Cheng Y Bin, Hwang T L, Chen B H and Chang F R 2017 Anti-allergic hydroxy fatty acids from *Typhonium blumei* explored through ChemGPS-NP *Front. Pharmacol.* 8

[8] Nurrochmad A, Ikawati M, Sari I P, Murwanti R and Nugroho A E 2015 Immunomodulatory effects of ethanolic extract of *Typhonium flagelliforme* (Lodd) Blume in rats induced by cyclophosphamide *J. Evidence-Based Complement. Altern. Med.* 20 167–72

[9] Jiang C D, Wang X, Gao H Y, Shi L and Chow W S 2011 Systemic regulation of leaf anatomical structure, photosynthetic performance, and high-light tolerance in sorghum *Plant Physiol.* 155 1416–24

[10] Li T, Liu L N, Jiang C D, Liu Y J and Shi L 2014 Effects of mutual shading on the regulation of photosynthesis in field-grown sorghum *J. Photochem. Photobiol. B Biol.* 137 31–8

[11] Casal J J 2013 Photoreceptor signaling networks in plant responses to shade *Annu. Rev. Plant Biol.* 64 403–27

[12] Arviola L 1981 Spectrophotometric determination of chlorophyll a and phaeo pigments in ethanol extracts *Ann. Bot. Fenn.* 18 221–7

[13] Cho A K, Haslett W L and Jenden D J 1960 A titerimetric method for the determination of creatine phosphokinase *Biochem. J.* 75 115–9

[14] Sáez-Plaza P, Michałowski T, Navas M J, Asuero A G and Wybraniec S 2013 An Overview of the kjeldahl method of nitrogen determination. Part I. Early History, Chemistry of the Procedure, and Titrimentic Finish *Crit. Rev. Anal. Chem.* 43 178–223

[15] Quinlan K P and de Sesa M A 1955 Spectrophotometric determination of phosphorus as molybdovanadophosphoric acid *Anal. Chem.* 27 1626–9

[16] Sahrawat K L 1980 A rapid nondigestion method for determination of potassium in plant tissue *Commun. Soil Sci. Plant Anal.* 11 753–7

[17] Zervoudakis G, Salahas G, Kaspiris G and Konstantopoulou E 2012 Influence of light intensity on growth and physiological characteristics of common sage (*Salvia officinalis* L.) *Brazilian Arch. Biol. Technol.* 55 89–95

[18] Rezaei S, Etemadi N, Nikbakht A, Yousefi M and Majidi M M 2018 Effect of light intensity on leaf morphology, photosynthetic capacity, and chlorophyll content in sage (*Salvia officinalis* L.) *Hortic. Sci. Technol.* 36 46–57

[19] Utami N, Devy L and Arianto A 2016 Growth and yield response of rodent tuber (*Typhonium flagelliforme* (Lodd.) Blume) under different light intensities and concentrations of paclobutrazol *J. Jamb J. Sci. Eng. Technol.* 1 29–35

[20] Beneragama C and Goto K 2011 Chlorophyll a:b ratio increases under low-light in “shade tolerant” *Euglena gracilis* *Trop. Agric. Res.* 22 12

[21] Dai Y, Shen Z, Liu Y, Wang L, Hannaway D and Lu H 2009 Effects of shade treatments on the photosynthetic capacity, chlorophyll fluorescence, and chlorophyll content of *Tetrastigma hemsleyanum* Diels et Gilg *Environ. Exp. Bot.* 65 177–82

[22] Ardie S W, Rahayu S, Susila A D 2001 Adaptsan tanaman *Hoya diversifolia* Blume pada intensitas cahaya tinggi *Agritrop J. Ilmu-Ilmu Pertan.* 14–9

[23] Khan S, Paliwal V, Pandey V V and Kumar V 2015 Biomass as renewable energy *Int. Adv. Res. J. Sci. Eng. Technol.* 2 301–4
[24] Sui Y and Harvey P J 2021 Effect of light intensity and wavelength on biomass growth and protein and amino acid composition of Dunaliella salina Foods 10
[25] Zhou J, Li P P, Wang J Z and Fu W 2019 Growth, photosynthesis, and nutrient uptake at different light intensities and temperatures in lettuce HortScience 54 1925–33
[26] Britzke D, da Silva L S, Moterle D F, dos Santos Rheinheimer D and Bortoluzzi E C 2012 A study of potassium dynamics and mineralogy in soils from subtropical Brazilian lowlands J. Soils Sediments 12 185–97
[27] Torabian S, Farhangi-Abriz S, Qin R, Noulas C, Sathuvalli V, Charlton B and Loka D A 2021 Potassium: a vital macronutrient in potato production—a review Agronomy 11
[28] Mokrani K, Hamdi K and Tarchoun N 2018 Potato (Solanum Tuberosum L.) Response to nitrogen, phosphorus and potassium fertilization rates Commun. Soil Sci. Plant Anal. 49 1314–30
[29] Shunka E, Chindi A, Giorgis G W, Seid E and Tessema L 2017 Determination of optimum nitrogen and potassium levels for potato production in central high lands of Ethiopia Open Agric. 2 189–94
[30] Schulz V S, Munz S, Stolzenburg K, Hartung J, Weisenburger S and Graeff-Hönninger S 2019 Impact of different shading levels on growth, yield and quality of potato (Solanum tuberosum L.) Agronomy 9
[31] Lestari P, Utami N W and Wawo A H 2019 Adaptasi intensitas cahaya rendah gembili (Dioscorea esculenta) pada naungan artifisial Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia vol 5 pp 374–82
[32] Soverda N, Evita and Gusniwati 2012 Pengaruh naungan terhadap kandungan nitrogen dan protein daun serta pertumbuhan dan hasil tanaman kedelai Bioplantae 1 1–9