



ISSN Print: 2664-844X
 ISSN Online: 2664-8458
 NAAS Rating (2026): 4.97
 IJAFS 2026; 8(4): 183-188
www.agriculturaljournals.com
 Received: 09-01-2026
 Accepted: 12-02-2026

Ishika Chauhan
 P.G. Scholar, Department of
 Botany, St. Xavier's College
 (Autonomous), Ahmedabad,
 Gujarat, India

Goral Jani
 Head and Assistant Professor,
 Department of Botany,
 Government Arts and Science
 College, Bavla, Gujarat, India

Maulik Gadani
 Associate Professor,
 Department of Botany, St.
 Xavier's College
 (Autonomous), Ahmedabad,
 Gujarat, India

Corresponding Author:
Ishika Chauhan
 P.G. Scholar, Department of
 Botany, St. Xavier's College
 (Autonomous), Ahmedabad,
 Gujarat, India

Influence of coconut water as a natural biostimulant through seed priming on phenolic and flavonoid content in radish and beet microgreens

Ishika Chauhan, Goral Jani and Maulik Gadani

DOI: <https://www.doi.org/10.33545/2664844X.2026.v8.i4c.1307>

Abstract

Microgreens are young, edible seedlings recognized for their high nutritional density and rich antioxidant content, making them important functional foods in modern diets. Traditional agricultural practices in India have long utilized natural plant-based substances such as coconut water to enhance seed vigour and crop quality. In this context, seed priming with natural biostimulants represents an eco-friendly strategy to improve microgreen quality. The present study aims to evaluate the effect of coconut water seed priming at different concentrations (10%, 20%, 30%, and 40%) on total phenolic and flavonoid content in radish and beet microgreens. The results revealed distinct, species-specific responses. In radish microgreens, the highest total phenolic content was observed in the control with a general decline under treatments, although 30% concentration remained comparable. In contrast, beet microgreens exhibited enhanced phenolic content at 10% and 40% compared to control, indicating a stimulatory effect at moderate concentrations. For flavonoids, radish microgreens showed the highest content in control, with reduction at lower concentrations and partial recovery at higher levels (30-40%). Conversely, beet microgreens recorded maximum flavonoid content at 10%, exceeding the control, followed by moderate levels at higher concentrations. Overall, coconut water priming exhibited a concentration-dependent and crop-specific influence on phytochemical accumulation. While radish microgreens showed limited enhancement, beet microgreens responded positively, particularly at 10% concentration. These findings highlight the potential of coconut water as a natural biostimulant for improving the nutritional and functional quality of microgreens. The observed effects may be associated with modulation of phenolic biosynthesis pathways.

Keywords: Microgreens, Seed Priming, Total Phenols, Flavanoids, Coconut water

Introduction

Microgreens are tender, immature greens harvested at the cotyledonary or first true leaf stage and are increasingly recognized as a novel category of functional foods due to their high nutritional density and rich antioxidant composition (Kyriacou *et al.*, 2016; Michell *et al.*, 2020) [8, 11]. These young seedlings typically include the cotyledons, hypocotyl, and emerging true leaves, and are commonly referred to as “vegetable confetti” because of their vibrant appearance and culinary appeal (Kyriacou *et al.*, 2016) [8]. A wide variety of crops such as radish, beet, cabbage, broccoli, mustard, and basil are commonly cultivated as microgreens (Stoleru *et al.*, 2016) [18]. Notably, microgreens have been reported to contain significantly higher concentrations of vitamins, minerals, and bioactive compounds often four to six times greater than their mature counterparts—making them an important component of modern health-conscious diets (Li *et al.*, 2021; Petropoulos *et al.*, 2021) [10, 16]. In recent years, the popularity of microgreens has increased substantially, particularly during and after the COVID-19 pandemic, as consumers have shifted toward fresh, nutrient-rich, and locally produced foods. Their ease of cultivation, short growth cycle, and suitability for urban agriculture further enhance their importance as sustainable food sources. Microgreens are especially valued for their abundance of phytochemicals, including phenolic compounds and flavonoids, which contribute to antioxidant activity and play a crucial role in reducing oxidative stress-related disorders (Bhaswant *et al.*, 2023) [1]. Additionally, phenolic compounds are known to influence sensory attributes such as bitterness and astringency, thereby affecting consumer acceptance (Caracciolo *et al.*, 2020) [3].

The successful production of high-quality microgreens depends on several factors, among which seed quality and germination efficiency are critical. Seed priming has emerged as an effective, low-cost, and environmentally friendly technique to enhance seed performance. This process involves controlled hydration of seeds to activate pre-germinative metabolic processes without initiating radicle emergence (Paparella *et al.*, 2015; Hussain *et al.*, 2018) [15, 5]. Seed priming improves germination rate, uniformity, and stress tolerance by promoting physiological and biochemical activities such as enzyme activation, repair of cellular components, and mobilization of stored reserves (Paparella *et al.*, 2015) [15]. Furthermore, priming treatments have been shown to shorten crop establishment time and improve overall yield and quality (Lee *et al.*, 2004) [9]. In the search for sustainable agricultural inputs, natural biostimulants have gained considerable attention. Coconut water, a natural liquid endosperm of *Cocos nucifera*, is rich in essential nutrients, including sugars, amino acids, vitamins, and minerals such as potassium, calcium, and magnesium (Nasution *et al.*, 2025) [14]. Importantly, it also contains natural plant growth regulators, particularly cytokinins and auxins, which are known to promote cell division and plant development. Due to its bioactive composition, coconut water has been explored as a natural growth enhancer and liquid fertilizer in various crops, with reported improvements in growth and productivity (Nasution *et al.*, 2025; Mergiana, 2021) [14, 12]. However, its effectiveness largely depends on the concentration applied, as optimal dosages are required to achieve beneficial effects. Despite increasing interest in microgreens and natural biostimulants, there is limited scientific evidence on the use of coconut water as a seed priming agent, particularly in relation to phytochemical enhancement. Moreover, studies focusing on its impact on key antioxidant compounds such as phenols and flavonoids in microgreens are scarce. Therefore, the present study aims to evaluate the effect of coconut water seed priming at different concentrations on the phenolic and flavonoid content of radish (*Raphanus sativus* L.) and beet (*Beta vulgaris* L.) microgreens, thereby providing insights into its potential as a natural biostimulant for improving functional food quality.

2. Materials and Methods

2.1 Experimental Site and Duration

The experiment was conducted in the Botany Laboratory of St. Xavier's College (Autonomous), Ahmedabad, Gujarat, India. The study was carried out over a period of two months, from December to January. All experimental procedures were performed under controlled indoor conditions suitable for microgreen cultivation.

2.2 Plant Material

Seeds of Radish (*Raphanus sativus* L.) and Beet (*Beta vulgaris* L.) were selected for the study. These species belong to the families Brassicaceae and Amaranthaceae, respectively, and are commonly used for microgreen production.

2.3 Seed Priming Treatments

Coconut water obtained from fresh tender coconuts was used as a natural biostimulant for seed priming. Different concentrations of coconut water were prepared using distilled water, namely 10%, 20%, 30%, and 40% (v/v). Distilled water without coconut water served as the control. Seeds of both radish and beet were subjected to priming treatments by soaking them in the respective solutions for a defined duration (6 hours). After priming, the seeds were air-dried under shade to restore their original moisture level before sowing.

2.4 Growing Conditions: Microgreens were grown in earthen pots containing a soilless growth medium composed of cocopeat and vermicompost in a 1:1 ratio. Prior to sowing, the pots were properly cleaned and prepared. After sowing, the pots were kept in a dark environment for 2-3 days to facilitate germination (etiolation), followed by exposure to indirect sunlight for further growth. Irrigation was carried out daily using a spray bottle to maintain adequate moisture. Microgreens were harvested at the stage of first true leaf emergence using sterilized scissors. Only healthy and uniform seedlings were selected for analysis, while discoloured or damaged samples were discarded. The harvested samples were gently washed to remove adhering particles and stored under refrigerated conditions until further analysis.

Microgreens	Control	10%	20%	30%	40%
Beet					
Radish					

2.5 Experimental Design

The experiment consisted of five treatments: control (0%), 10%, 20%, 30%, and 40% coconut water concentrations. Each treatment was applied to both plant species. The experiment was conducted in triplicates to ensure statistical reliability.

2.6 Phytochemical analysis

Fresh microgreen samples (100 mg) were accurately weighed and homogenized with 80% methanol using a mortar and pestle. The homogenate was centrifuged at 7000-9000 rpm for 15 minutes. The resulting supernatant was

carefully collected and filtered to obtain a clear extract, which was used for subsequent biochemical analyses.

Total Phenolics

The total phenolic content of beet (*Beta vulgaris*) and radish (*Raphanus sativus*) microgreens was determined using the Folin-Ciocalteu colorimetric method (Bray & Thorpe, 1954). An aliquot of 1 mL of the plant extract (supernatant) was taken in a test tube, to which 1 mL of 20% sodium carbonate (Na_2CO_3) solution was added. Subsequently, 0.5 mL of Folin-Ciocalteu reagent (1N) was added, and the mixture was thoroughly mixed. The reaction mixture was then incubated in a boiling water bath for 10 minutes to facilitate color development. After incubation, the tubes were allowed to cool to room temperature. The final volume was adjusted to 20 mL using distilled water and kept undisturbed for complete color stabilization. The absorbance of the developed blue color was measured at 660 nm using a UV-Visible spectrophotometer against a reagent blank, which was prepared by replacing the extract with distilled water. The total phenolic content was calculated using the regression equation of tannic acid standard: $X = 400Y - 0.001$ where:

- X = Total phenolic content (mg/g plant material)
- Y = Absorbance at 660 nm

The results were expressed as mg phenols per gram of plant material. The sets were carried out in triplicates and the values were statistically analysed and expressed as Mean $\pm$ Standard Error (SE).

Total Flavanoids

The total flavanoids content of beet (*Beta vulgaris*) and

radish (*Raphanus sativus*) microgreens was determined using the aluminium chloride (AlCl_3) colorimetric method with quercetin as the standard (Kim, Jeong & Lee, 2003) [6]. Fresh microgreen samples were extracted using 80% methanol as described previously. An appropriate aliquot of the methanolic extract was taken, and aluminium chloride reagent was added to the reaction mixture, followed by sodium acetate. The mixture was then incubated at room temperature for 10-15 minutes to allow the formation of a flavonoid-aluminium complex. The absorbance of the reaction mixture was measured at 512 nm using a UV-Visible spectrophotometer against a suitable blank. A standard calibration curve was prepared using different concentrations of quercetin, and the corresponding absorbance values were recorded. Total flavonoid content was calculated using the regression equation obtained from the quercetin standard curve: $X = (Y + 0.0161) / 0.1571$ where:

- X = Total Flavanoid content (mg/g plant material)
- Y = Absorbance at 512 nm

The results were expressed as milligrams of quercetin equivalents (mg QE) per gram of fresh weight. All measurements were carried out in triplicates, and the values were expressed as mean $\pm$ standard error (SE).

3. Results and Discussion

3.1 Total Phenols

The total phenolic content (TPC) of radish and beet microgreens under different concentrations of coconut water seed priming is presented in Table 1 & Figure-1. The results indicate that coconut water priming had a differential effect on phenolic accumulation in both species.

Table 1: TPC of Radish & Beet Microgreens under different concentrations of Coconut Water Seed Priming

Sr. No.	Treatments	Total Phenols	
		Radish (mg/gm)	Beet (mg / gm)
1	Control	4.5199 $\pm$ 0.0326	1.5599 $\pm$ 0.0498
2	10%	3.5999 $\pm$ 0.1543	2.0265 $\pm$ 0.0576
3	20%	3.4665 $\pm$ 0.0392	1.2265 $\pm$ 0.0544
4	30%	4.2532 $\pm$ 0.0108	1.1599 $\pm$ 0.1359
5	40%	3.8265 $\pm$ 0.0108	1.9065 $\pm$ 0.0288

In radish microgreens, the highest phenolic content was recorded in the control, while all treatments showed a reduction in TPC. Among the treatments, 30% coconut water exhibited values closest to the control, whereas the lowest phenolic content was observed at 20% concentration. The reduction in phytochemical content in radish suggests that coconut water may act as a regulatory factor rather than

a stimulant, depending on species-specific metabolic sensitivity. In contrast, beet microgreens showed a stimulatory response to coconut water priming. The highest phenolic content was observed at 10% concentration, followed by 40%, both of which were higher than the control. However, intermediate concentrations (20% and 30%) resulted in reduced phenolic content.

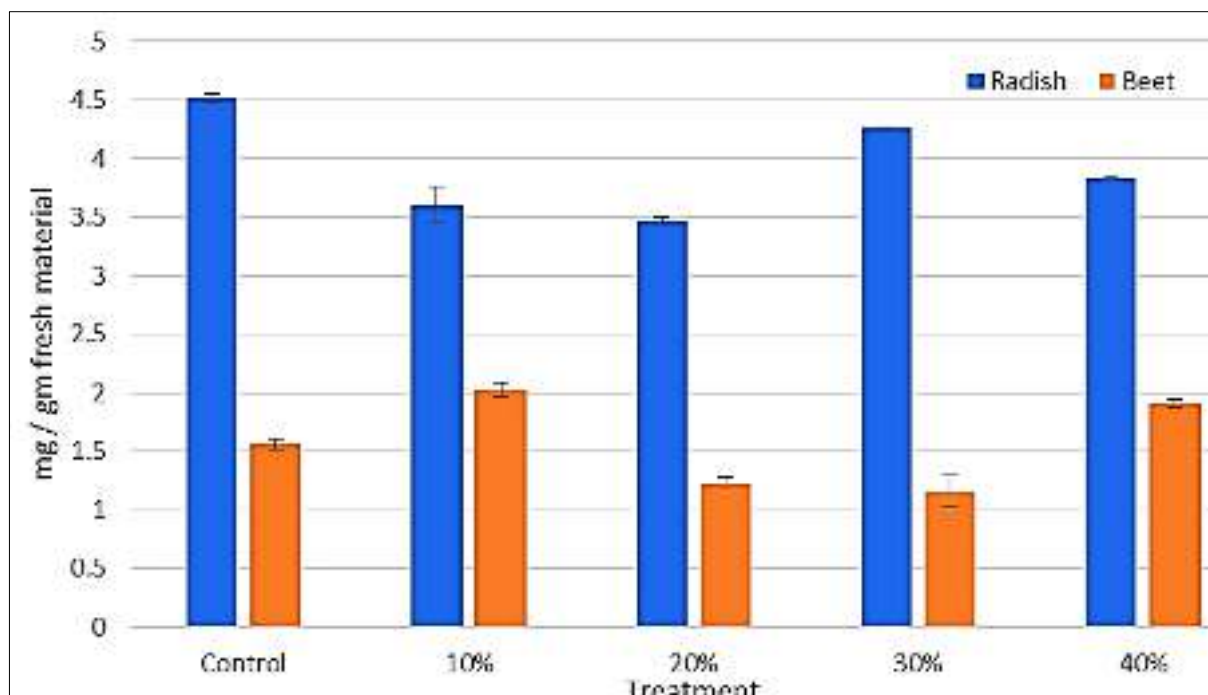


Fig 1: Shows Total Phenols in microgreens

The increase in phenolic compounds in beet microgreens may be attributed to the presence of natural growth regulators such as cytokinins and auxins in coconut water, which can enhance secondary metabolite biosynthesis. Phenolic compounds are synthesized as part of plant defense mechanisms and are often induced under mild stress or elicitation conditions. Similar observations have been reported where external treatments stimulate phenolic accumulation as a physiological response to environmental or chemical stimuli (Paparella *et al.*, 2015) ¹⁵. The contrasting response between radish and beet suggests

species-specific metabolic regulation, where beet microgreens are more responsive to biostimulant-induced phenolic enhancement, while radish exhibits sensitivity leading to reduced accumulation.

3.2 Total Flavanoids

The total flavonoid content (TFC) of radish and beet microgreens under different concentrations of coconut water seed priming is presented in Table 2 & Figure-2. The results revealed a concentration-dependent and species-specific variation in flavonoid accumulation.

Table 2: Total Flavanoids of Radish & Beet Microgreens under different concentrations of Coconut Water Seed Priming

Sr. No.	Treatments	Flavanoids	
		Radish (mg/gm)	Beet (mg / gm)
1	Control	0.84086 ± 0.0030	0.43348 ± 0.0108
2	10%	0.69658 ± 0.0017	0.54169 ± 0.0051
3	20%	0.64353 ± 0.0030	0.41438 ± 0.0030
4	30%	0.76660 ± 0.0075	0.43560 ± 0.0017
5	40%	0.78569 ± 0.0017	0.48864 ± 0.0017

In radish microgreens, the highest flavonoid content was recorded in the control, while all coconut water treatments resulted in a reduction in TFC. Among the treatments, the lowest flavonoid content was observed at 20% concentration, whereas higher concentrations (30% and

40%) showed partial recovery, approaching control values. This trend suggests that coconut water priming does not enhance flavonoid biosynthesis in radish and may exert a regulatory or inhibitory effect at certain concentrations, possibly due to metabolic sensitivity to exogenous inputs.

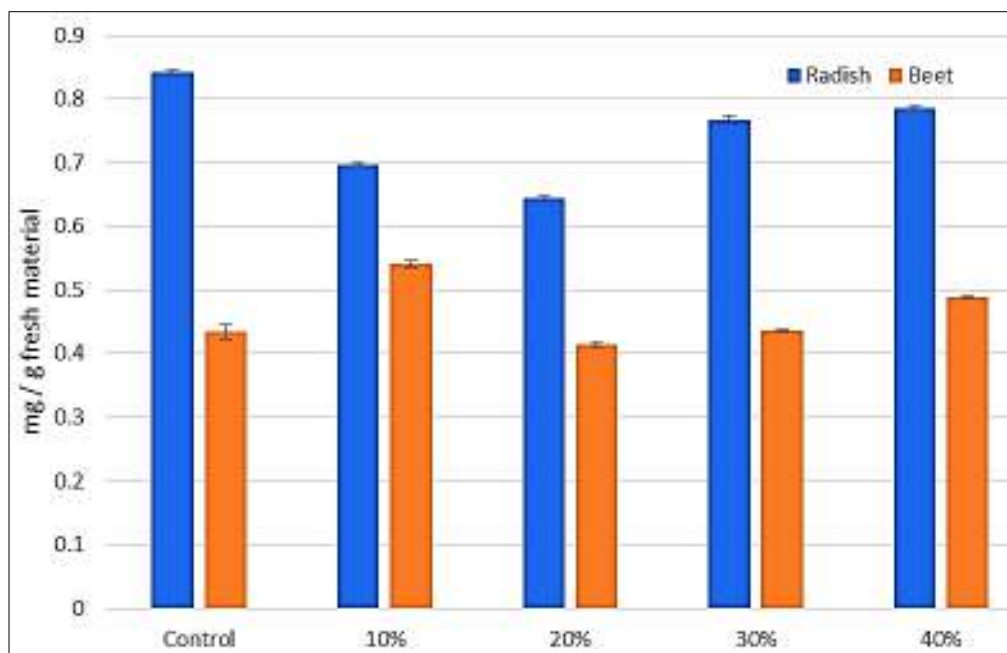


Fig 2: Total Flavanoid Content under different concentrations of Coconut Water

In contrast, beet microgreens exhibited a positive response to coconut water priming. The highest flavonoid content was observed at 10% concentration, which exceeded the control, followed by moderate increases at 30% and 40%. However, a decline was noted at 20% concentration. This indicates that lower concentrations of coconut water are more effective in stimulating flavonoid accumulation, while intermediate levels may not be optimal.

Flavonoids are a major class of polyphenolic secondary metabolites synthesized through the phenylpropanoid pathway and play a crucial role in plant defense and antioxidant activity (Tungmunthum *et al.*, 2018; Kumar *et al.*, 2023) [19, 7]. These compounds are known to accumulate in response to environmental stimuli, stress conditions, and elicitor treatments, thereby enhancing the plant's protective mechanisms (Nakabayashi *et al.*, 2014) [13]. The phenylpropanoid pathway is highly responsive to external inputs, which can trigger increased biosynthesis of flavonoids under favorable or stress-induced conditions (Kumar *et al.*, 2023) [7].

The enhancement of flavonoid content in beet microgreens may therefore be attributed to the presence of natural plant growth regulators and nutrients in coconut water, which can act as elicitors of secondary metabolism. Similar findings have been reported where external treatments and improved cultivation conditions significantly enhance flavonoid accumulation in microgreens and other plant systems (Samuolienė *et al.*, 2019; Kyriacou *et al.*, 2016) [17, 8]. Such increases are often associated with mild physiological stress or signaling responses that activate antioxidant pathways (Tungmunthum *et al.*, 2018) [19].

On the other hand, the reduction observed in radish microgreens suggests that excessive or non-optimal concentrations of coconut water may disrupt metabolic balance, thereby limiting flavonoid biosynthesis. This further indicates that secondary metabolite production is highly dependent on plant species, metabolic sensitivity, and treatment conditions.

The contrasting trends observed between radish and beet emphasize that the effect of coconut water priming is not uniform but governed by species-specific metabolic

regulation. While beet microgreens respond positively to optimal concentrations, radish appears to exhibit a more sensitive or inhibitory response, reinforcing the importance of crop-specific optimization of natural biostimulants.

5. Conclusion

Coconut water seed priming exhibited a clear concentration-dependent and species-specific effect on phytochemical accumulation in microgreens, with beet showing enhanced phenolic and flavonoid content at 10% concentration, while radish displayed no improvement. These contrasting responses reveal that coconut water functions as a regulator rather than a universal enhancer of secondary metabolism. The study underscores the importance of crop-specific optimization of natural biostimulants and provides meaningful insight into their targeted application for improving microgreen nutritional quality. Further studies are required to elucidate the underlying biochemical and molecular mechanisms governing the species-specific response to coconut water priming. Such investigations would help in optimizing its application across a wider range of microgreen crops.

References

1. Bhaswant M, Shanmugam DK, Miyazawa T, Abe Chizumi, Miyazawa T. Microgreens- A Comprehensive Review of Bioactive Molecules and Health Benefits. *Molecules*. 2023;28(2):867-91. doi: 10.3390/molecules28020867.
2. Bray HG, Thorpe WV. Analysis of phenolic compounds of interest in metabolism. *Methods in Biochemical Analysis*. 1954;1:27-52.
3. Caracciolo F, El-Nakhel C, Raimondo M, Kyriacou MC, Cembalo L, Pascale S, Roupheal Y. Sensory attributes and consumer acceptability of 12 microgreens species. *Agronomy*. 2020;10(7):1043-58. doi: 10.3390/agronomy10071043.
4. Ebert AW, Chang CH, Yan MR, Yang RY. Nutritional composition of mungbean and soybean sprouts compared to their adult growth stage. *Food Chem*. 2017;237:15-22. [CrossRef].

5. Hussain M, Farooq S, Hasan W, Ul-Allah S, Tanveer M, Farooq M, Nawaz A. Drought stress in sunflower: Physiological effects and its management through breeding and agronomic alternatives. *Agric Water Manag.* 2018;201:152-66. [CrossRef].
6. Kim DO, Jeong SW, Lee CY. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. *Food Chem.* 2003;81(3):321-326.
7. Kumar S, Korra T, Thakur R, Arutselvan R, Kashyap AS, Nehela Y, Keswani C. Role of plant secondary metabolites in defense and transcriptional regulation in response to biotic stress. *Plant Stress.* 2023;100154.
8. Kyriacou MC, Rouphael Y, Di Gioia F, Kyrtzis A, Serio F, Renna M, Pascale S, Santamaria P. Micro-scale vegetable production and the rise of microgreens. *Trends Food Sci Technol.* 2016;57(11):103-15. doi: 10.1016/j.tifs.2016.09.005.
9. Lee J, Pill W, Cobb B, Olszewski M. Seed treatments to advance greenhouse establishment of beet and chard microgreens. *J Hort Sci Biotechnol.* 2004;79:565-70. [CrossRef].
10. Li T, Lalk GT, Arthur JD, Johnson M, Bi G. Shoot production and mineral nutrients of five microgreens as affected by hydroponic substrate type and post-emergent fertilization. *Horticulturae.* 2021;7(6):129-46.
11. Michell KA, Isweiri H, Newman SE, Bunning M, Bellows LL, Dinges MM, Grabos LE, Rao S, Foster MT, Heuberger AL, Prenni JE, Thompson HJ, Uchanski ME, Weir T, Johnson S. Microgreens: Consumer sensory perception and acceptance of an emerging functional food crop. *J Food Sci.* 2020;85(4):926-35. doi: 10.1111/1750-3841.15075.
12. Mergiana A. Efektivitas air kelapa tua (*Cocos nucifera* L.) terhadap pertumbuhan tanaman anggur hijau (*Vitis vinifera* L.) varietas Jestro Ag-86. 2021;2(1):516-521.
13. Nakabayashi R, Yonekura-Sakakibara K, Urano K, Suzuki M, Yamada Y, Nishizawa T, Saito K. Enhancement of oxidative and drought tolerance in *Arabidopsis* by overaccumulation of antioxidant flavonoids. *Plant J.* 2014;77(3):367-79.
14. Nasution A, Dalimunthe BA, Rizal K, Triyanto Y. Utilization of Coconut Water Waste as Liquid Organic Fertilizer for the Growth of Mung Bean Microgreens (*Vigna radiata*). *Jurna Agronomi Tanaman Tropika.* 2025;7(1):320-325. DOI: <https://doi.org/10.36378/juatika.v7i1.4215>.
15. Paparella S, Araújo SS, Rossi G, Wijayasinghe M, Carbonera D, Balestrazzi A. Seed priming: State of the art and new perspectives. *Plant Cell Rep.* 2015;34(8):1281-93. doi: 10.1007/s00299-015-1784-y.
16. Petropoulos SA, El-Nakhel C, Graziani G, Kyriacou M, Rouphael Y. The effects of nutrient solution feeding regime on yield, mineral profile, and phytochemical composition of spinach microgreens. *Horticulturae.* 2021;7(7):162-76. doi: 10.3390/horticulturae7070162.
17. Samuolienė G, Brazaitytė A, Sirtautas R, Viršilė A, Sakalauskienė S, Duchovskis P. LED illumination affects bioactive compounds in romaine baby leaf lettuce. *J Sci Food Agric.* 2019;99(2):678-84.
18. Stoleru T, Ionita A, Zamfirache MM. Microgreens—A new food product with great expectations. *Rom J Biol.* 2016;61(1&2):7-16.
19. Tungmunthum D, Thongboonyou A, Pholboon A, Yangsabai A. Flavonoids and other phenolic compounds from medicinal plants for pharmaceutical and medical aspects: An overview. *Medicines.* 2018;5(3):93.