

Sustainable Soilless Cultivation of Leafy Vegetables: Evaluating Nutrient Media Performance in EcoPeat-Grown Amaranthus and Spinach

Dr. T. Annie Sheron and Dr. K. Usha Rani,

Department of Botany, Government Degree College for Women, Begumpet, Hyderabad.

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ABSTRACT

Soilless cultivation has emerged as a sustainable alternative to conventional agriculture, particularly in urban and resource-limited environments. The present study evaluates the performance of different nutrient media on the growth of *Amaranthus viridis* and *Spinacia oleracea* cultivated in EcoPeat (cocopeat). Four treatments were employed: Control (water), Hydroponic Nutrient Solution (N1), Vermiwash (N2), and Vegetable Wash (N3). Growth parameters including root length, shoot length, and leaf number were recorded over a four-week period. Results indicated that nutrient-supplemented treatments significantly enhanced plant growth compared to control. In Amaranthus, hydroponic solution promoted early root establishment, while vermiwash and vegetable wash enhanced shoot growth and leaf proliferation. Vegetable wash (N3) showed the highest leaf production, indicating superior vegetative growth. In spinach, vermiwash (N2) consistently supported robust shoot development, while hydroponic solution (N1) resulted in better root growth. Organic nutrient media demonstrated sustained performance due to microbial activity and gradual nutrient release. The study highlights that eco-friendly nutrient sources such as vermiwash and vegetable wash can effectively replace chemical nutrient solutions in soilless systems. These findings support sustainable urban agriculture practices, reduced environmental impact, and cost-effective food production. The integration of EcoPeat with organic nutrient media offers a viable approach for enhancing productivity and achieving food security.

Keywords: Soilless cultivation, EcoPeat, Amaranthus, Spinach, Vermiwash, Sustainable agriculture.

INTRODUCTION

Global population growth, urbanization, and land degradation have led to an urgent need for sustainable and space-efficient agricultural practices. Soilless farming has emerged as a modern solution capable of addressing constraints related to soil

infertility, water scarcity, and limited arable land availability (FAO, 2012; Jhahria *et al.*, 2016). Soilless cultivation, particularly hydroponics, allows precise management of nutrients and water, offering a clean, controlled environment for crop production (Barrett *et al.*, 2016; Marschner, 2012).

Cocopeat—a substrate derived from coconut husk—has gained popularity due to its high water-holding capacity, good aeration, and renewable nature (Taiz and Zeiger, 2010). However, cocopeat is nutrient-inert and must be supplemented with nutrient media. Nutrient delivery systems such as hydroponic solutions, vermiwash, and fermented vegetable wash differ in their composition and impact on plant growth (Despommier, 2013; Kumar *et al.*, 2020).

Rapid population growth, declining arable land, and environmental degradation have intensified the need for sustainable agricultural practices (Despommier, 2013; Jhahria *et al.*, 2016). Conventional soil-based farming faces challenges such as nutrient depletion, water scarcity, and pollution. Soilless cultivation, particularly substrate-based systems using cocopeat, offers an efficient alternative by enabling precise nutrient management and improved resource utilization (FAO, 2012; Rathinavel *et al.*, 2018).

Cocopeat (EcoPeat), derived from coconut husk, is widely used due to its excellent water retention, aeration, and eco-friendly nature (FAO, 2012). However, being nutrient-deficient, it requires external supplementation. Nutrient media such as hydroponic solutions, vermiwash, and vegetable wash differ in nutrient availability and biological activity, thereby influencing plant growth (Barrett *et al.*, 2016; Kumar *et al.*, 2020).

Leafy vegetables like *Amaranthus viridis* and *Spinacia oleracea* are ideal plants for cocopeat-based soilless cultivation due to their short growth cycles and high nutritional value. Their responsiveness to nutrient inputs makes them suitable for evaluating the effectiveness of different nutrient media (Rathinavel *et al.*, 2018).

The objective is to identify the most effective medium for promoting growth and yield in urban environments.

MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Department of Botany, Government Degree College for Women (Autonomous), Begumpet, Hyderabad

2.2 Selection of Plants

Two green leafy vegetables were selected based on their nutritional and cultural significance:

- *Amaranthus viridis* (Thotakura)
- *Spinacia oleracea* (Spinach)

2.3 Growing Media

Sterilized cocopeat (Ecopeat) was used in all pots as the soilless growing medium.

2.4 Nutrient Media

Four treatments were tested:

- **Control (C):** Municipal water (pH 8–8.2, TDS < 100 ppm)
- **Hydroponic Nutrient Solution (N1):** Prepared using a standard formula (Fernandes, 2021)
- **Vermiwash (N2):** Liquid extract from 3-month vermicompost diluted 1:20 with water
- **Vegetable Wash (N3):** Fermented vegetable waste solution (Bokashi method), diluted 1:20

2.5 Procedure

Seeds were soaked for 24 hours and sown in 5×5-inch thermoformed pots filled with cocopeat. The plants were maintained under ambient light and temperature with daily watering. Morphological parameters such as root length, shoot length, and leaf count were recorded weekly for four weeks, and four replicates were maintained for each treatment

Nutrient Analysis (Rathinavel *et al.*, 2018).

- Moisture content: Gravimetric oven-drying method.
- Total ash: Incineration at 600°C in a muffle furnace.
- Vitamin C: DCPIP dye titration.
- Calcium: EDTA complexometric titration after acid digestion
- Iron: Wong's colorimetric spectrophotometric method.

RESULTS AND DISCUSSION

3.1 Growth Performance of *Amaranthus viridis*

3.1.1 Weekly growth observations under Different Nutrient Media

Amaranthus showed a clear variation in growth across treatments over the four-week period (Table 1). In Week 1, hydroponic media (N1) recorded the highest root length

(3.8 cm), likely due to the immediate availability of soluble nutrients (Marschner, 2012). Vermiwash (N2) produced the tallest shoots (9.3 cm), which may be attributed to the presence of growth-promoting substances such as humic compounds and plant hormones (Sreelatha *et al.*, 2016). Vegetable wash (N3) showed the highest leaf number (6), indicating early stimulation of leaf development by organic nutrients and microbial activity (Kumar *et al.*, 2020).

Table1: Weekly Comparative Analysis of Leaf Number, Root Length, and Shoot Length of *Amaranthus viridis* Under Different Nutrient Media (C, N1, N2, N3)

Duration	1st week			2nd week			3rd week			4th week		
Media	Leaf No	root	shoot	Leaf No	root	shoot	Leaf No	root	shoot	Leaf No	root	shoot
Control	4	0.6	6.8	6	2.6	9	5	3.2	10	5	2.5	8.4
N1	4	3.8	7.5	4	1.4	8.9	5	3.8	13.8	8	4.2	21.6
N2	4	1.5	9.3	6	1.8	8	9	3	14	9	2.2	14.3
N3	6	2	7.1	8	1.9	11.9	11	4.3	20.5	13	6.2	24.8

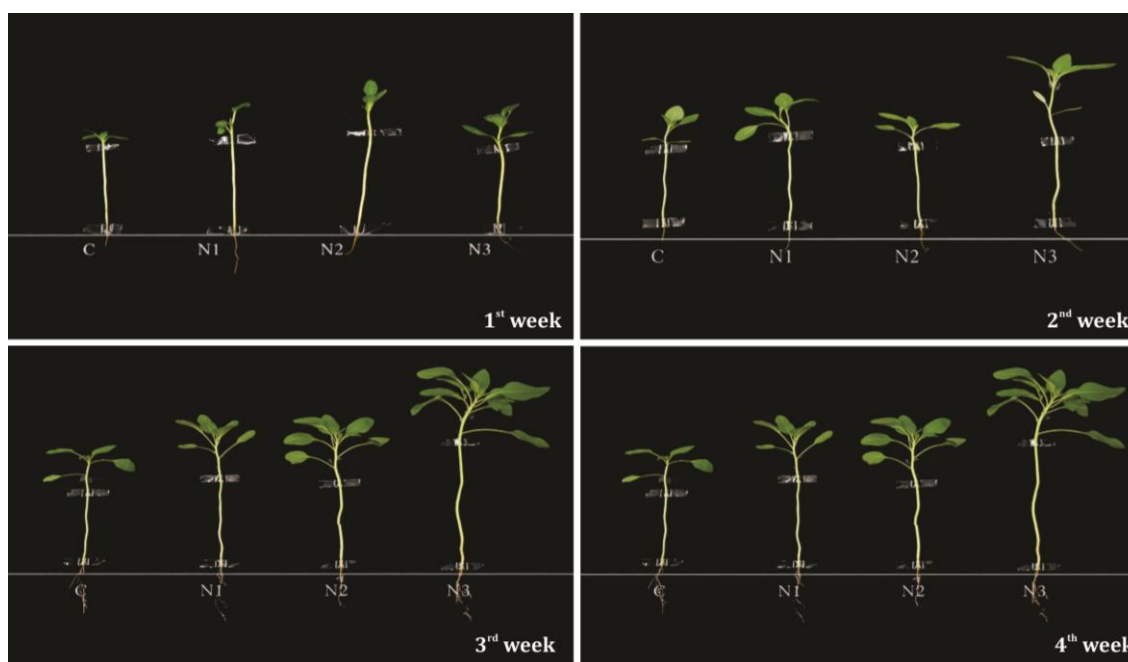


Figure 1: Root, Shoot and leaf Development in *Amaranthus* Across Four Weeks Under Varying Nutrient Treatments

Table 2: Nutrient analysis of *Amaranthus viridis* after 4 weeks of cultivation

Treatment	Moisture (%)	Ash (g)	Vitamin C (mg)	Calcium (mg)	Iron (mg)
Hydroponic (N1)	79.2	1.56	NR	207.8	12.0
Vermiwash (N2)	51.1	3.0	NR	117.2	5.2
Veg. Wash (N3)	95.0	1.6	NR	128.8	NR

By Week 2, N3 performed best, producing the longest shoots (11.9 cm) and the highest leaf count (8). This may be due to the gradual release of nutrients from decomposed vegetable matter and improved microbial activity (Kramer and Boyer, 1995). Control plants showed slower growth, indicating nutrient limitation (Taiz and Zeiger, 2010).

In Week 3, the control plants showed tall shoots (20.0 cm) but fewer leaves (6), which is typical of etiolation caused by nutrient deficiency (Taiz and Zeiger, 2010). In contrast, N3 showed both tall shoots (20.5 cm) and higher leaf number (9), indicating healthy and productive growth (Jhahria *et al.*, 2016).

Overall, vegetable wash (N3) showed the best performance in terms of growth and leaf production, followed by vermiwash (N2) which supported balanced development. Hydroponic media (N1) was effective in early growth, while control plants consistently showed the least performance due to lack of nutrients.

By Week 4, N3 gave the best overall results with root length of 6.2 cm, shoot length of 24.8 cm, and 13 leaves, clearly outperforming other treatments ((Jhahria *et al.*, 2016; Taiz and Zeiger, 2010). Hydroponic media also showed good shoot growth (21.6 cm) with 8 leaves, reflecting efficient nutrient supply (Marschner, 2012). Vermiwash produced a good number of leaves (9), likely due to organic growth promoters (Gajalakshmi and Abbasi, 2015, Sreelatha *et al.*, 2016). Control plants showed the least growth, confirming the need for nutrient supplementation in soilless systems (Taiz and Zeiger, 2010).

3.1.2 Nutrient Analysis after 4th week of growth

Nutrient analysis at Week 4 showed clear differences among treatments (Table 4). Vegetable wash (N3) recorded the highest moisture content (95%), indicating better hydration and tender leaves suitable for fresh consumption (Kramer and Boyer, 1995). Vermiwash (N2) showed lower moisture (51.1%), suggesting higher dry matter content (Taiz and Zeiger, 2010). Ash content was highest in N2 (3.0 g), followed by N3 (1.6 g) and hydroponic media (1.56 g), indicating better mineral availability in vermiwash-treated plants (Marschner, 2012). Hydroponic treatment (N1) recorded the highest calcium (207.8 mg) and iron (12.0 mg), due to readily available nutrients in soluble form (Kumar *et al.* 2024, White and Broadley, 2003). Vitamin C was not detected in any treatment.

3.2 Growth Performance of Spinach (*Spinacia oleracea*)

3.2.1 Weekly growth observations under Different Nutrient Media

Spinach was grown in cocopeat under four nutrient treatments for four weeks, with root length, shoot length, and leaf number recorded weekly (Table 3). In Week 1, vermiwash (N2) showed the highest root (4.1 cm) and shoot growth (5.9 cm), likely due to growth-promoting substances such as auxins and humic compounds (Kumar, *et al.*2024). All treatments showed uniform germination with two leaves per plant.

By Week 2, N2 continued to show the highest root growth (4.5 cm), indicating better nutrient uptake supported by microbial activity (Marschner, 2012). Hydroponic media (N1) recorded higher leaf number (3 leaves), suggesting efficient nutrient supply for leaf development.

Table 3: Weekly Comparative Analysis of Leaf Number, Root Length, and Shoot Length of *Spinacia oleracea* Under Different Nutrient Media (C, N1, N2, N3)

Duration	1st week			2nd week			3rd week			4th week		
Media	Leaf No	root	shoot	Leaf No	root	shoot	Leaf No	root	shoot	Leaf No	root	shoot
Control	2	2	5.2	2	2.2	5.8	2	3.5	7.4	5	4.0	8.5
N1	2	3	5.7	3	3.3	6	4	3.3	8.2	5	5.2	10
N2	2	4.1	5.9	2	4.5	6.4	2	3.6	7.9	5	5	12.9
N3	2	3	5.4	2	3.1	6.2	2	3.7	6.2	4	3.8	11.1

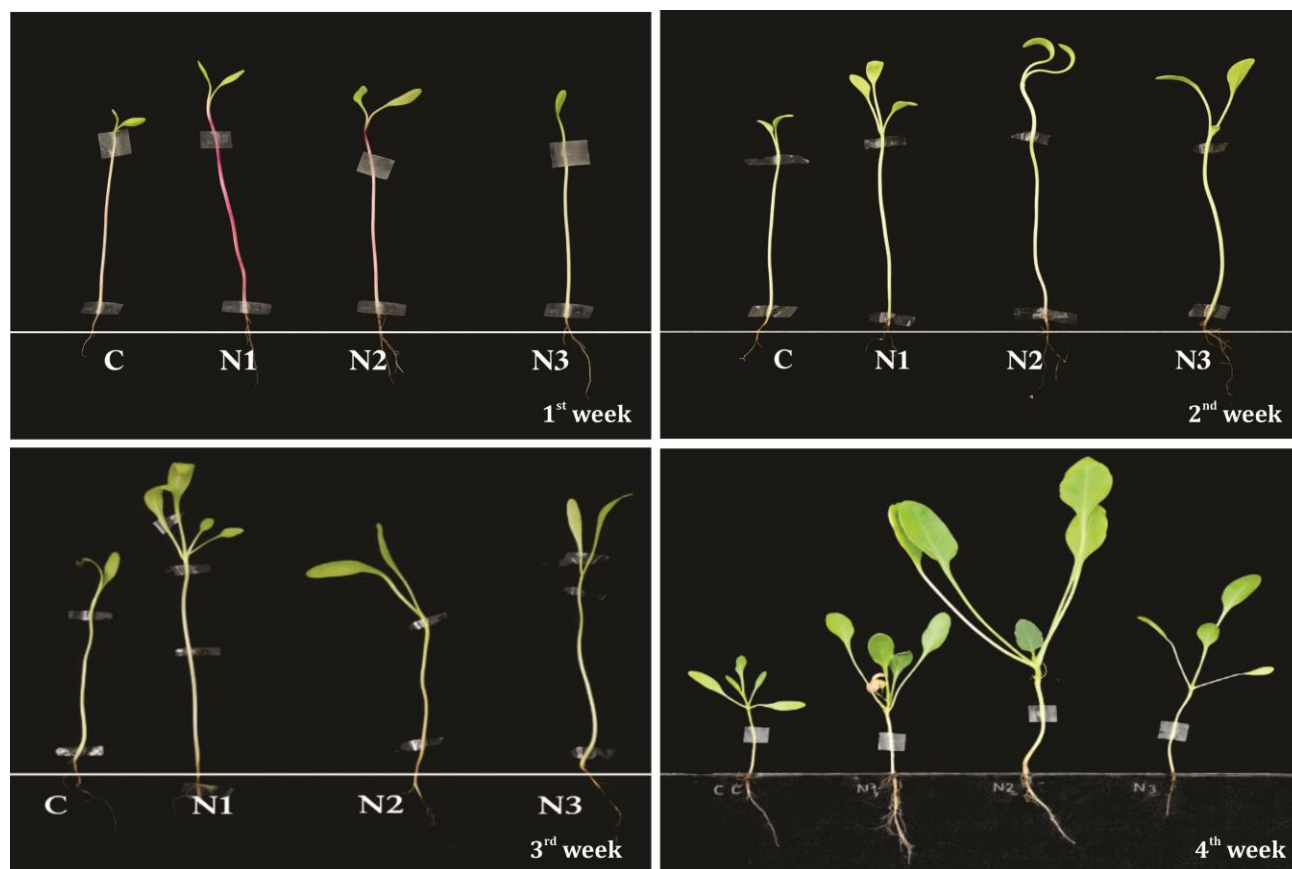


Figure 2: Root, shoot and leaf development in *Spinach oleracea* across 4 weeks under varying nutrient treatments

Table 4: Nutrient analysis of *Spinach oleracea* after 4 weeks of cultivation

Media	Moisture %	Ash (g)	Vitamin C (mg)	Calcium (mg)	Iron (mg)
Hydroponic media (N1)	79.7	16.7	39.45	208.6	NR
Vermiwash (N2)	80.0	1.56	NR	50	9.6
Vegetable wash (N3)	84.7	1.0	18.75	141	5.2

In Week 3, hydroponic treatment showed the highest shoot length (8.2 cm) and leaf number (4), indicating good nutrient availability and active growth while control plants showed moderate shoot growth but fewer leaves, indicating stress due to nutrient deficiency (Taiz and Zeiger, 2010).

By Week 4, vermiwash again showed the highest shoot growth (12.9 cm), while hydroponic media recorded the highest root length (5.2 cm). Vegetable wash (N3) also showed good shoot growth (11.1 cm), suggesting gradual nutrient release (Kumar *et al.*, 2020). Control plants showed the lowest growth, confirming the need for nutrients in cocopeat systems.

3.2.2. Nutrient Analysis:

Nutrient analysis of spinach after Week 4 showed clear differences among treatments (Table 2). Vegetable wash (N3) recorded the highest moisture (84.7%), followed by vermiwash (80.0%) and hydroponic media (79.7%), indicating better leaf hydration under organic treatments (Kramer and Boyer, 1995).

Ash content was highest in hydroponic plants (16.7 g), showing higher mineral uptake. Vitamin C was highest in N1 (39.45 mg), followed by N3 (18.75 mg). Calcium was also highest in hydroponic treatment (208.6 mg) due to readily available nutrients (White and Broadley, 2003).

Iron content was highest in vermiwash (9.6 mg), likely due to organic compounds improving iron availability.

Overall, vermiwash (N2) supported the best shoot growth and balanced development in spinach, while hydroponic media (N1) enhanced root growth and nutrient content. Vegetable wash (N3) showed good vegetative growth, whereas control plants consistently recorded the lowest performance due to nutrient limitation.

CONCLUSION

This study shows that soilless cultivation in cocopeat is an effective method for growing leafy vegetables, but the choice of nutrient medium is very important for growth and nutritional quality. All nutrient treatments performed better than the control, confirming that cocopeat alone cannot support plant growth.

In spinach, vermiwash (N2) gave better shoot growth, while hydroponic media (N1) improved root growth and nutrient content. In amaranthus, vegetable wash (N3) showed the best overall growth and leaf production, while hydroponic media provided higher mineral content.

Overall, vermiwash and vegetable wash are eco-friendly and low-cost alternatives to chemical nutrients and support sustainable urban farming. The study suggests selecting nutrient media based on purpose—vegetable wash for higher biomass, vermiwash for better growth, and hydroponics for higher nutrient content. Further studies can focus on long-term use and large-scale application.

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Correspondence and requests for materials should be addressed to **Dr. T. Annie Sheron**

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REFERENCES

- Barrett GE, Alexander PD, Robinson JS, Bragg NC (2016) Achieving environmentally sustainable growing media for soilless plant cultivation systems: A review. *Scientia Horticulturae* 212: 220–234. doi:10.1016/j.scienta.2016.09.030
- Despommier D (2013) Farming up the city: The rise of urban vertical farms. *Trends in Biotechnology* 31(7): 388–389. doi:10.1016/j.tibtech.2013.03.008
- FAO (2012) The state of the world's land and water resources for food and agriculture. Food and Agriculture Organization of the United Nations.
- Fernandes D (2021) Standard hydroponic nutrient solution formulation manual. Hydroponics India Publications.
- Gajalakshmi S, Abbasi SA (2015) Earthworms, vermicompost and vermiwash: Ecological tools for sustainable organic farming. *Dynamic Soil, Dynamic Plant* 9: 1–12.
- Jhajhria A, Kumar K, Jat S (2016) Vermicompost and vermiwash effect on growth and yield attributes of fenugreek. *International Journal of Current Microbiology and Applied Sciences* 5(7): 413–420.
- Kramer PJ, Boyer JS (1995) Water relations of plants and soils. Academic Press.
- Kumar V, Saini SK, Verma R (2020) Fermented vegetable waste as an organic nutrient source for soilless cultivation. *Journal of Organic Agriculture* 14(3): 55–63.
- Lee SK, Kader AA (2000) Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology* 20(3): 207–220.
- Marschner H (2012) Mineral nutrition of higher plants (3rd ed.). Academic Press.
- Raghuramulu N, Nair MK, Kalyanasundaram S (2003) A manual of laboratory techniques (2nd ed.). National Institute of Nutrition.
- Rathinavel K, Bhavani G, Balakrishnan K (2018) Influence of substrates on seedling production of spinach and fenugreek under soilless conditions. *International Journal of Horticulture* 8(10): 87–95.

- Savvas D, Passam HC (2002) Hydroponic production of vegetables and ornamentals. Embryo Publications.
- Sreelatha M, Sureshkumar P, Arulselvi PI (2016) Effect of vermiwash on growth and yield of spinach and fenugreek. *Journal of Biochemistry and Biotechnology* 5(1): 45–52.
- Taiz L, Zeiger E (2010) *Plant physiology* (5th ed.). Sinauer Associates.
- Tamnineni Varu Kumar C, *et al* (2024) Nutrient media influence on growth parameters of leafy vegetables in soilless cultivation. *Indian Journal of Sustainable Agriculture* 12(2): 88–97.
- White PJ, Broadley MR (2003) Calcium in plants. *Annals of Botany* 92(4): 487–511.

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