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Evaluating the Potential of Coconut Biomass Waste as a Growing Medium

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Authors' contributions

This work was carried out in collaboration among all authors. Author VPG was involved in conducting the experiment, carrying out laboratory and statistical analysis work and preparing the draft manuscript. Author NKB had proposed the research work, supervised the work and corrected the manuscript. Author BVU was involved in correcting the final manuscript and checked the data. Author PN and PKR had extended valuable suggestions for the laboratory work. All authors read and approved the final manuscript.

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Abstract

Coconut biomass waste is a sustainable resource used for industrial, agricultural and household applications. Based on the concept of diversified use and value addition of coconut biomass waste, the coconut shell, wood, leaf and husk were collected, powdered and incorporated in growing media at different proportions and assessed for chilli germination and seedling growth behaviour by conducting a protray seedling raising experiment. The treatments were T_1, T_2, T_3, T_4 and T_5, prepared by mixing soil, sand, coconut biomass waste and cow dung in the ratio 1:1:0:1, 1:0.5:0.5:1, 1:0:1:1, 1:0:2:1, 0:0:2:1 respectively. The growing medium of T_5 (Treatment with higher

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proportion of coconut biomass waste) had high nutrient content, organic matter content, lignin content and salt concentration with very low pH, followed by T_4, T_3, T_2 and T_1. Whereas T_1 (Control) exhibits early germination, high germination percentage and low mortality percentage, followed by T_2. Moreover, control is the better performer in case of seedling growth behaviour. whereas T_5 showing comparatively higher shoot growth. This result suggests that high lignin and salt content with low-pH environments had a negative influence on chilli seed germination and seedling growth. Hence addition of coconut biomass waste directly in growing medium without any pretreatment is nonsignificant while comparing to the control (without coconut biomass waste). However, the high nutrient content and physical properties of the media with higher proportion of coconut biomass waste enlighten the scope of using the same as substrate with proper pretreatments.

Keywords: Chilli seedling; coconut biomass waste; germination and growth behaviour; growing media.

1. Introduction

Biowaste valorization has gained wide attention over the past few years as a better alternative for the management of agricultural waste. Especially in the development of environmentally sound and innovative methods to process such waste is emerging as an area of increasing interest. Instead of disposing and decomposing biowaste, recent researches had focused on its utilization in various ways (Arancon et al., 2013).

The use of soil-less substrates in crop production has become very common, not only for growing seedlings and propagation of plants but also for vegetable production. The high cost and low availability of soilless media like peat, perlite, zeolite etc. leads to an urgency to go for alternative materials (Abad et al., 2001) like treated agricultural wastes due to their higher availability and low cost nature (Capanoglu et al., 2022). The European Union has published ordinances to bring down the use of peat in growing media and has supported research with composted organic wastes.

Chilli (*Capsicum annuum* L.), is a solanaceous vegetable crop extensively cultivated in India, as a vegetable as well as a spice. Production of healthy and vigorous pepper seedlings is an important factor in the successful commercial production and yield of quality chilli fruits which is majorly influenced by the physical nature and chemical constitution of growing media (Kaledzi et al., 2020). Seedling emergence and early growth are critical for crop establishment and higher yield (E'rahim et al., 2021). KNO_3 (1%) treatment for 24 hours can enhance seedling germination in chilli (Maphalaphathwa and Nciizah, 2025).

Coconut is a palm with high economic value, cultivated across 12 million hectares area, producing over 65.7 billion nuts annually (FAO, 2022). Even though the consumer demand for coconut-based products were very high, the industry faces significant challenges also. Aging palms, pests, diseases, and climate change are the major threats to productivity (Alouw et al., 2025). This results availability of huge quantity of coconut biomass waste which was an excellent raw material for diverse value-added products. Besides these the processing of coconut products accumulates a large amount of agricultural waste, which poses an environmental risk if it is left untreated (Hoang et al., 2023). Coir pith and cocopeat are well suited as a constituent of growing media due to their ability to improve soil physical properties and act as a soil conditioner, though it requires proper washing and nutrient addition for optimal plant growth. In the present study the raw coconut biomass waste (shell, wood, leaf and husk) all together were utilized as the constituent of growing media and evaluated its suitability for seedling growth in protrays.

2. Materials and Methods

2.1 Preparation of Different Combinations of Growing Media

The coconut biomass waste materials like coconut shell, husk, leaf and wood were collected from the farm, College of Agriculture, Padannakkad, Kasaragod, Kerala, India (located at 12°15'25" N and 75°07'05" E) and powdered using shredder and thresher machines (Bharath agritech, Maharashtra) (NAHEP-CAAST). The powdered material was sundried and make a mixture of coconut shell, wood, leaf and husk in the ratio 1:1:2:2.

Different combinations (five) of growing media were prepared by mixing soil, sand, coconut biomass waste powder and cow dung in different ratios. Treatment 1 was growing medium having soil, sand, coconut biomass waste powder and cow dung in the ratio 1:1:0:1, which was control. In treatment 2, treatment 3, treatment 4 and treatment 5, the ratios were 1:0.5:0.5:1, 1:0:1:1, 1:0:2:1 and 0:0:2:1 respectively.

2.2 Analysis of Different Combinations of Growing Media

Nutrient content of growing media were determined by acid digestion followed by estimation methods. Total nitrogen was measured using modified Kjeldhal digestion method. Total phosphorus was measured by vanadomolybdate yellow colour method using UV- visible spectrophotometer (Labman scientific instruments). Available potassium was determined by flame photometric method (Systronics, Model 128). Estimation of exchangeable calcium and magnesium done by EDTA titration method. Available Sulphur was estimated turbidometrically using spectrophotometric method (Tabatabai, 1982) (Labman scientific instruments). Besides these parameters, pH, EC, organic matter content and lignin content of the growing media were determined using pH meter, EC meter, muffle furnace and soxhlet apparatus respectively.

2.3 Chilli Seedling Raising Experiment

An experiment of raising chilli seedlings in protrays was conducted from October to December 2025, at College of Agriculture, Padannakkad, Kasaragod, Kerala, India (12°15’25” N and 75°07’05” E). Experimental design was CRD (completely randomized design) with five treatments and four replications. A single portray with maximum of 98 seedling capacity was taken as a replication. Chilli variety Ujwala seeds were purchased from instructional farm I, Padannakkad, Kasaragod, Kerala and subjected for seed priming with 1% potassium nitrate for better germination (Maphalaphathwa and Nciizah, 2025). Seed germination test was conducted prior to setting up of experiment, which resulted poor germination percentage for untreated seeds compared to the seeds treated with 1% potassium nitrate. 98 seeds were sown in each portrays and number of days for leaf emergence, number of days for transplanting, length of shoot and root at time of transplanting (cm), Dry weight of shoot and root (g), germination percentage (%) and mortality percentage (%) were recorded.

2.4 Statistical Analysis

The observations were statistically analyzed in a completely randomized design using the GRAPES (Kerala Agricultural University) software (Gopinath et al., 2020). Duncan’s multiple range test (DMRT) values were calculated at the 5% probability level (p = 0.05) to compare treatment means.

3. Results and Discussion

This research focus on the comparative evaluation of five different growing media with soil, sand, coconut biomass wastes and cow dung in different combinations, to understand the germination and growth behaviour of chilli seedlings in these media.

3.1 Chemical Properties of Different Combinations of Growing Media

Total primary and secondary nutrient content was higher in T_5 (treatment with higher proportion of Coconut biomass waste) followed by T_4, T_3, T_2 and least for T_1 (control) (Table 1). There was a clear linear progression in the concentration of total N, P and K across the five treatments. From T_1 to T_5, total Nitrogen increased from 1.05 to 1.61%, Total Phosphorus increased from 0.12% to 0.43% and Total potassium and calcium showed variation. This suggests that the treatments are effectively scaling the availability of primary and secondary nutrients. Total sulphur was also lower in control (0.17%) and higher for treatment with high proportion of coconut biomass waste (0.3%). Total magnesium content varies slightly among treatments (Table 1). The results showed that coconut biowastes could provide required essential nutrients to the crop in high quantities.

There is an inverse relationship between organic matter content and pH across the treatments. As the organic matter content increased from control (20.8%) to T_5 (82.6%), the pH falls significantly (6.75 to 4.6). This acidification is likely driven by the accumulation of organic acids and the substantial rise in electrical conductivity (EC), which was 0.56 dSm^{-1} for control and 3.3 dSm^{-1} for treatment with high proportion of coconut biomass waste (T_5) (Table 2). The Lignin content showed a nearly six times rise (4.29% in control and 25.66% in T_5) which implies that as the treatments progresses T_1 to T_5, the material becomes significantly more recalcitrant and carbon rich. Meanwhile high EC coupled with high acidity and lignin content denotes that the treatment with high proportion of coconut biomass waste (T_5) is a very rich source of nutrients, though its high salt concentration and low pH may affect the seed germination and seedling rise.which can be corrected by appropriate pretreatments.

3.2 Seed Germination and Seedling Growth Behaviour in Different Combinations of Growing Media

In case of seedling emergence behaviour, control treatment (without coconut biomass waste) recorded early germination (8 days) and attaining transplanting maturity (32 days) with high germination percentage (76.79%) and low mortality percentage (1.96%). Whereas treatment with high proportion of coconut biomass waste (T_5) recorded late germination (14.75 days), T_3 had low germination percentage (52.80%) and high mortality percentage (9.69%). T_3 and T_4 were on par for all the observed parameters except mortality percentage (Table 3).

The data reveals that while control (without coconut biowaste) promoted the rapid seedling emergence in just 8 days and reaching transplanting readiness point towards the higher organic treatments significantly delayed growth. As the organic matter and EC increased in T_3 and T_4, germination decreased substantially and mortality peaked at 9.69% (T_3), likely due to the high acidity (pH 4.7–5.7) and salt stress identified. Nutrients are most available to plants for growth in the optimum at a pH 6.5 to 7.0 range (Kaledzi et al., 2020). Very low pH may reduce availability of nutrients though present in sufficient quantities in the media. Salt stress can affect germination and seedling growth either by creating an osmotic pressure that prevents absorption of water or due to the toxic effects of salt (Sarkar and Sadhukhan 2023). Interestingly, treatment with high proportion of coconut biomass waste (T_5) showed a slight improvement in germination, suggesting that despite the slow growth rate, the high nutrient content and low density of the medium eventually supports the germination.

The control T_1 was significantly different and better performing in accordance with growth behaviour, compared to the other treatments, those which contain coconut biomass waste as a constituent. At 30 days after sowing, control was almost ready for transplanting with comparatively high shoot length (7.2 cm), root length (7.2 cm) and dry matter weight (0.056g). There was no significant difference between other treatments (T_2, T_3, T_4 and T_5) in case of shoot length. Treatment with high proportion of coconut biomass waste (T_5) had least shoot length whereas T_3 (growing medium having soil, sand, coconut biomass waste powder and cow dung in the ratio 1:0:1:1) and T_4) growing medium having soil, sand, coconut biomass waste powder and cow dung in the ratio 1:0:2:1) had recorded least root length. Dry matter weight was also lowest for T_5. At the time of transplanting, control had recorded highest shoot length (7.2 cm) while Treatment with high proportion of coconut biomass waste (T_5) had recorded highest root length (9.7). Dry matter weight was nearly similar for all the treatments, hence there was no significant difference among the treatments (Table 4).

Table 1. Total nutrient content of different combinations of growing media

	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)	Total Mg (%)	Total S (%)
T_1	1.05	0.12	0.20	0.56	0.24	0.17
T_2	1.12	0.19	0.34	0.64	0.29	0.23
T_3	1.19	0.33	0.43	0.8	0.29	0.25
T_4	1.4	0.35	0.76	1.12	0.34	0.26
T_5	1.61	0.43	0.78	1.52	0.29	0.30
SE (m)	0.013	0.003	0.006	0.009	0.004	0.005
CD	0.039	0.010	0.018	0.027	0.011	0.015

Table 2. Chemical characteristics of different combinations of growing media

	P^H	EC (dSm^{-1})	Organic matter (%)	Lignin (%)
T_1	6.75	0.56	20.8	4.29
T_2	6.02	0.99	36.2	9.45
T_3	5.71	1.31	54.2	15.35
T_4	4.77	1.88	64.4	19.26
T_5	4.6	3.3	82.6	25.66
SE (m)	0.060	0.017	0.233	0.102
CD	0.182	0.051	0.704	0.306

Table 3. Seedling emergence behaviour in different combinations of growing media

	Number of days for seedling emergence	Number of days for transplanting	Germination percentage (%)	Mortality percentage (%)
T_1	8.00^{d}	32.00^{d}	76.79^{a}	1.96^{c}
T_2	11.50^{c}	45.00^{c}	76.02^{a}	2.63^{bc}
T_3	13.50^{b}	54.00^{a}	52.80^{b}	9.69^{a}
T_4	14.00^{b}	54.00^{a}	53.82^{b}	6.11^{ab}
T_5	14.75^{a}	52.00^{b}	57.29^{b}	5.46^{bc}
SE (m)	0.21	0.32	2.12	1.33
CD	0.65	0.95	6.40	3.99

Table 4. Seedling growth behaviour in different combinations of growing media

	Shoot length (cm)		Root length (cm)		Dry matter weight g)	
	30 Days after sowing	Transplanting	30 Days after sowing	Transplanting	30 Days after sowing	Transplanting
T_1	7.20^{a}	7.20^{a}	7.03^{a}	7.03^{c}	0.056^{a}	0.056
T_2	4.40^{b}	6.80^{ab}	3.55^{c}	7.67^{bc}	0.017^{b}	0.058
T_3	3.65^{b}	6.55^{b}	3.23^{c}	7.58^{bc}	0.013^{bc}	0.058
T_4	3.58^{b}	5.90^{c}	3.23^{c}	8.80^{ab}	0.011^{c}	0.047
T_5	3.55^{b}	6.45^{b}	4.83^{b}	9.70^{a}	0.011^{c}	0.052
SE (m)	0.34	0.15	0.45	0.42	0.002	0.004
CD	1.03	0.45	0.96	1.26	0.006	-

At 30 days after Sowing (DAS), control (without coconut biowaste) was significantly superior with respect to all parameters, while all other treatments showed inferior resulta. However, by the Transplanting stage, the trend shifts. Treatment with high proportion of coconut biomass waste (T_5) showed an exponential progress in root development, registering the highest root length. This suggests that though high organic matter and salt content with low-pH environments initially stunted early vigour, later coconut biomass waste based media eventually stimulate the growth of root systems at the time of transplanting, which may also be influenced by the density of the media.

A study conducted by Colla, et al. (2007) indicated that adding coir to peat at a coir:peat ratio of about 1.0 increased the root growth as a result of the better aeration of the root zone. Moreover, increasing the coir/peat ratio above 1.0 increased root growth at the expense of shoot growth. Reduced shoot growth was attributed to the soluble N immobilization by microorganisms due to the high C/N ratio in the coir (Arenas et al., 2002). Jayasinghe (2014) compared coir growing media and compost growing media at various combinations by growing ipomia plant. compost gave the highest yield and growth parameters like plant height, shoot fresh weight and shoot dry weight compared to 100% coir control. This was due to the low nutrient availability and high EC of coconut based media.

4. Conclusion

This experiment effectively performed the comparative evaluation of five types of growing media by growing chilli seedlings (Ujwala). Five treatments were opted for the study which includes T_1 (Control) with no coconut biomass waste and T_2 to T_5 with different combination of sand, soil, coconut biomass waste and cow dung. Seed germination and seedling growth parameters were analysed and the control T_1 showed better results compared to all the others, followed by T_2. The treatments with high content of coconut biomass waste are having high nutrient content and organic matter content but under performing due to its high lignin and salt content coupled with low pH. Hence the study concludes that coconut biomass waste is suitable for growing chilli seedlings only after proper pretreatments to reduce its salt content and lignin content.

Disclaimer (Artificial Intelligence)

During the preparation of this work the author(s) used OpenAI's Google Gemini tool in order to improve the language and readability of the manuscript. The AI did not contribute to the original data analysis, interpretation, or the initial drafting of the manuscript's scientific content. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Competing Interests

Authors have declared that no competing interests exist.

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