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Optimizing Soil Mixes for Efficient Seedling Growth: A Comparative Study Using Organic Fertilizer, Cocopeat, and Pineapple Leaf Residues

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Abstract. This study was conducted to evaluate the effects of various soil mixture types on the growth of *Brassica rapa* seedlings. The objectives of the study include identifying the most suitable soil composition to support early-stage seedling development and comparing the physical growth rates of the seedlings throughout the study period. Three types of soil mixtures were tested: organic fertilized soil, organic fertilized soil mixed with cocopeat, and organic fertilized soil mixed with pineapple leaf residues. The seedlings were cultivated under controlled environmental conditions, and growth parameters were recorded at regular intervals. The findings indicated that the appropriate soil mixture contributed to the most consistent and vigorous seedling growth. This study is expected to support the selection of effective, economical, and readily available planting media, particularly for small-scale farmers and urban agriculture applications.

Keywords: Pineapple Leaf, Agriculture Waste, Planting Media, Agriculture.

1. INTRODUCTION

Seedling establishment is a critical stage in crop production, as the quality of the growing medium directly influences plant vigor, survival rate, and overall yield potential [1]. However, conventional soil use often presents limitations such as poor aeration, nutrient imbalance and increased production costs when supplemented with commercial growing media or soil amendments. Therefore, alternative and more cost-effective growing media have been widely explored. In response to these challenges, the exploration of alternative, sustainable, and affordable soil mixtures have become increasingly important, particularly for small-scale farmers and urban agriculture practitioners who require accessible resources [2]. Previous studies have highlighted the potential of organic amendments, including cocopeat and agricultural residues, to enhance soil structure and nutrient availability, yet their effectiveness in supporting seedlings remains underexplored [3].

Early seedling growth plays a crucial role in determining overall crop quality and productivity. Agricultural residues such as pineapple leaf waste have recently gained attention as sustainable soil amendments; however, their Early seedling growth plays a crucial role in determining overall crop quality and productivity. Agricultural residues such as pineapple leaf waste have recently gained attention as sustainable soil amendments; however, their effectiveness during the early seedling stage may be limited by slow decomposition rates and temporary nutrient immobilization if used without pre-treatment [4] . Therefore, this study evaluated the early growth performance of seedlings grown in three soil mixtures: 100% organic soil as the base medium, organic soil mixed with cocopeat, and organic soil mixed with pineapple leaf waste. The objectives of this study were to identify the most suitable soil composition to promote strong and consistent seedling development and to compare the growth performance of seedlings across different soil mixtures.

2. Literature Review

Seedling establishment is strongly influenced by the physicochemical properties of the growing medium. Prior research consistently shows that media with balanced aeration, water-holding capacity, and nutrient availability promote higher emergence, faster early growth, and better root architecture in leafy vegetables [5]. Organic amendments are widely used to improve these properties by enhancing cation exchange capacity, microbial activity, and aggregation, which in turn stabilize moisture and nutrient supply during the vulnerable seedling stage.

Organic fertilized soil (i.e., soil amended with composted or organic nutrient sources) is frequently reported to support robust early growth due to slow-release macro- and micronutrients and improved soil structure [6]. However, the performance of organic-amended soils alone can vary with raw material quality, decomposition stage, and salinity, leading some studies to recommend blending with structurally stable, inert components to moderate bulk density and pore distribution.

Cocopeat (coir pith) is one such component. The literature highlights cocopeat's high porosity and water-holding capacity, low bulk density, and relatively inert chemical profile, which together enhance root aeration and reduce water stress in containerized seedlings [3]. Yet, cocopeat is typically low in intrinsic nutrients and may exhibit initial K and Na levels that require buffering; therefore, best performance is often achieved when cocopeat is combined with nutrient-bearing substrates or supplemented with organic fertilizers.

Work on *Brassica rapa* seedlings indicates sensitivity to both moisture regime and substrate porosity: overly compact media hinder hypocotyl elongation and root proliferation, while overly inert, nutrient-poor media limit early biomass accumulation without fertilization. Consequently, blended media that pair structural components (e.g., cocopeat or fibrous residues) with nutrient sources (e.g., organic-fertilized soil) are repeatedly recommended to balance structure and fertility [7].

Despite broad evidence on organic amendments and cocopeat, there is limited head-to-head evaluation of organic fertilized soil alone, organic fertilized soil with cocopeat blends and organic fertilized soil with pineapple leaf residue blends specifically for *Brassica rapa* seedlings under controlled conditions. Studies on pineapple leaf as a seedling medium remain sparse, often focusing on compost quality or fibre extraction rather than seedling performance metrics. Moreover, many reports emphasize endpoint biomass or survival rather than temporal growth rates (e.g., height increment, leaf initiation rate) tracked at regular intervals. Few investigations frame outcomes in terms of practical suitability for small-scale and urban agriculture, integrating performance with criteria of cost, local availability, and ease of handling [2].

The current work directly compares three realistic, locally accessible media which is organic fertilized soil, its blend with cocopeat, and its blend with pineapple leaf residue by using *Brassica rapa* seedlings grown under controlled conditions with growth parameters recorded at defined intervals [8]. By focusing on consistency and vigor of early growth, the study contributes comparative evidence on media performance, clarifies the potential of pineapple leaf as a sustainable component, and frames findings around effective, economical, and readily available options for smallholders and urban growers.

3. Research Methodology

This study employed an experimental research design to evaluate the effects of different soil mixture types on the early-stage growth of *Brassica Rapa* seedlings. The experiment was conducted under controlled environmental conditions to minimize external variability such as temperature, humidity, and sunlight exposure. A comparative approach was used, whereby seedlings were cultivated in three different soil mixtures, and their growth performance was systematically monitored and analysed over a defined period. The unused pineapple leaves were collected from local farms, thoroughly cleaned, air-dried, and subsequently oven-dried to ensure a low moisture content. The oven-drying process took up to 8 hours at a temperature of 65ºC, as shown in Figure 1. Once dried, the leaves were ground into a fine powder using a milling machine.

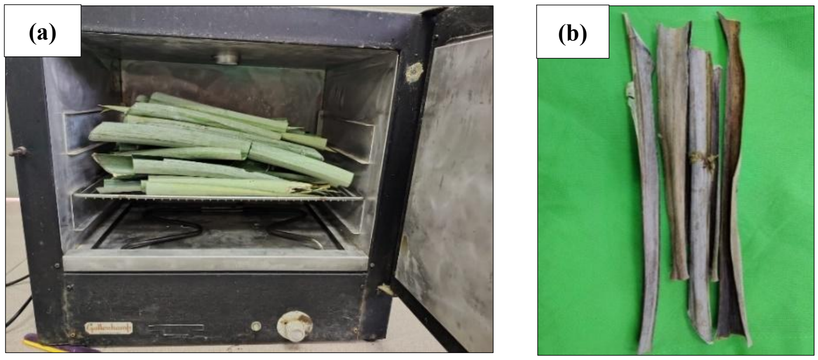

Figure 1: Drying process of pineapple leaves (a) Pineapple leaves being dried in the oven (b) Leaves after the drying process.

The main materials included *Brassica Rapa* seeds, organic fertilized soil, cocopeat and pineapple leaf. Table 1 shows the percentage ratio of sample preparation (SP) meanwhile Figure 2 shows the real sample preparation of soil, pineapple leaf and cocopeat which utilize in this study. The soil mixtures were prepared as Figure 2 below.

Figure 2: The soil mixtures between (SP1) 100 % of soil (SP2) 70% soil, 30% pineapple leaf (SP3) 70% soil, 30% cocopeat

Table 1: Percentage mixture between soil, pineapple leaves and cocopeat.

Sample Preparation (SP)	Percentage Soil (%)	Percentage Pineapple Leaf (%)	Percentage Cocopeat (%)
SP1	100		
SP2	70	30	
SP3	70		30

Brassica rapa was selected as the test crop in this study due to several advantages. It exhibits a fast germination rate, with seedlings emerging within two to three days, allowing for rapid observation of soil mix effects on early growth. It also has a short life cycle, typically reaching maturity within 20–30 days, which makes it highly suitable for short-term experimental trials and repeated replications.

In addition, it is highly responsive to variations in soil nutrients and structure, making it an effective indicator plant for evaluating the efficiency of different soil amendments. The seeds are inexpensive, widely available, and easy to cultivate under local conditions. Furthermore, *Brassica rapa* growth is generally uniform, which facilitates reliable comparisons between treatments. Importantly, mustard is a widely consumed leafy vegetable in Southeast Asia, ensuring that the findings of this study are relevant and applicable to local agricultural practices.

Seedling trays were used as planting containers. Measuring instruments such as a ruler (for height measurement) were employed to ensure accuracy. Seedlings were observed from germination to the seedling stage. Growth parameters measured at regular intervals (everyday) included:

- Plant height (cm).
- Number of leaves.
- Leaf length and width (cm).
- General seedling vigour (visual assessment of colour and uniformity).

All measurements were recorded systematically in data sheets, and photographs were taken to document visual differences across treatments.

4. RESULTS

Soil served as the primary growth medium in this study, with plant growth responses differing according to the composition of the mixtures tested. Three sample were prepared: 100% soil, 70% soil + 30% cocopeat, and 70% soil + 30% pineapple leaves. *Brassica Rapa* seed growth was evaluated daily by recording leaf development, plant height, and overall plant vigour.

The findings revealed that *Brassica Rapa* seeds grown in 100% soil exhibited a relatively slow initial growth rate, which could be attributed to compaction and limited aeration caused by soil preparation methods [9]. Similarly, the treatment containing soil and pineapple leaves showed delayed and stunted growth. This was most likely due to the slow decomposition rate of pineapple leaves, which require sufficient time to mineralise before contributing essential nutrients. In addition, their acidic properties may have created an unfavourable environment for early seedling establishment [10].

In contrast, the mixture of soil with cocopeat demonstrated the most favourable results. *Brassica Rapa* seeds in this treatment showed vigorous growth, attributed to the loose and fibrous texture of cocopeat which enhanced aeration and facilitated root penetration [11]. Moreover, cocopeat possesses a high water-holding capacity, ensuring consistent soil moisture, and its near-neutral pH helped stabilise the growth medium [12]. These properties collectively created optimal conditions for plant development.

On the ninth day of observation (Figure 3a), the treatment of sample 3, 70% soil + 30% pineapple leaf outperformed the other mixtures, producing the highest plant growth rate. The sample 2, 70% soil + 30% cocopeat treatment showed moderate improvement, while the sample 1, 100% soil remained the least effective. Growth differences between the three treatments are further illustrated in Figure 4.

Interestingly, despite differences in growth rate and plant height, the three treatments showed similar leaf development trends (Figure 3b). This indicates that while soil amendments significantly influence root establishment and shoot elongation during the early growth phase, leaf production appears to be less affected within the short observation period.

Overall, these results highlight the potential of cocopeat as a sustainable soil amendment for improving crop growth performance, while the use of pineapple leaves may require further optimisation, such as pre-treatment or composting, to enhance nutrient availability and reduce acidity before incorporation into soil mixtures.

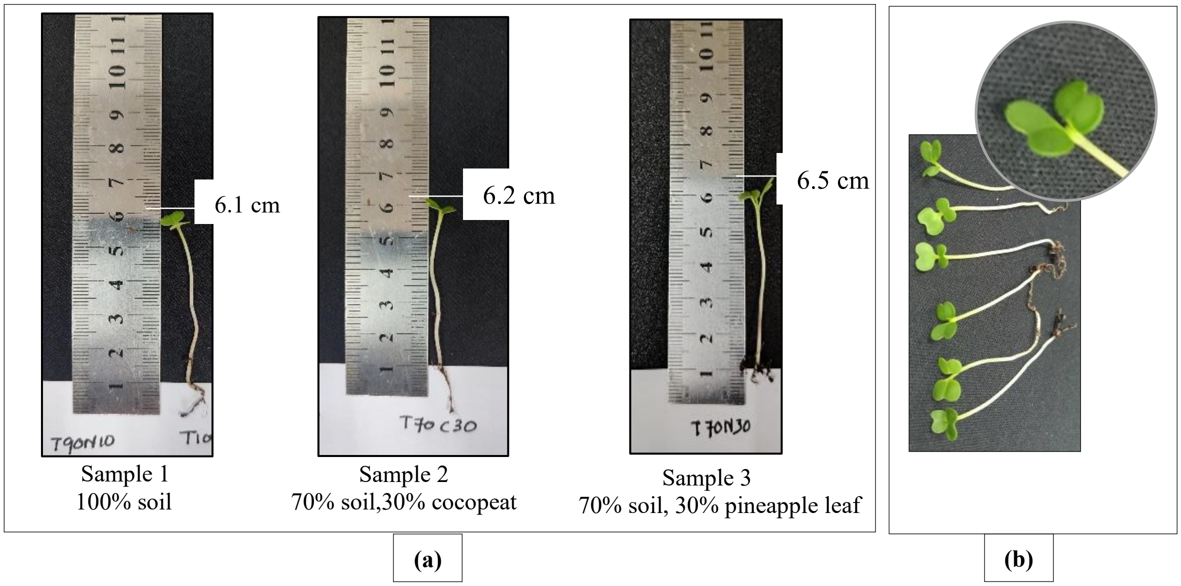

Figure 3: **(a)** Length and Growth Performance of *Brassica Rapa* on different soil mixtures, **(b)** The growth of leaves on different soil mixtures

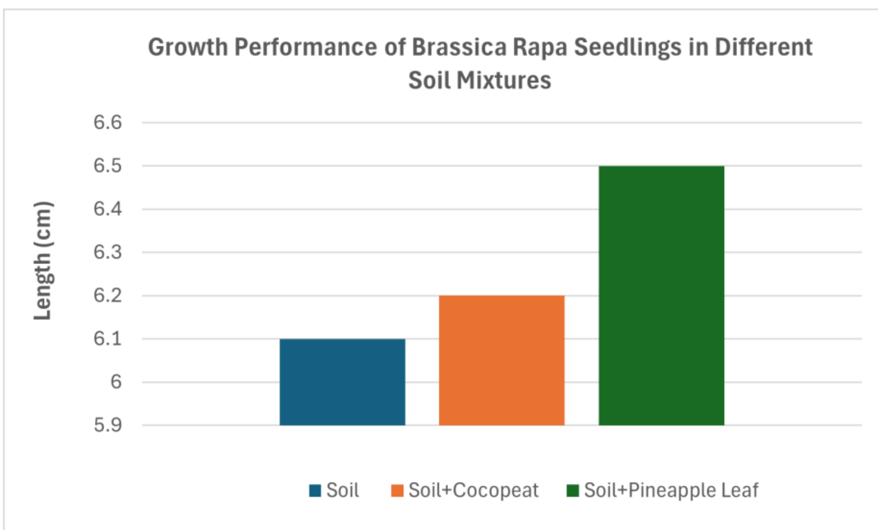

Figure 4: Graph of Growth Performance of *Brassica Rapa* Seedlings in Different Soil Mixtures.

The findings support the hypothesis that soil mixture influences the growth of *Brassica rapa* seedlings. Among the tested mixtures, the combination of organic fertilized soil with pineapple leaf was the most effective in promoting consistent and vigorous seedling growth, fulfilling both study objectives.

5. Discussion

The findings of this study demonstrate that soil mixture composition significantly affects the early-stage growth of *Brassica rapa* seedlings. Among the tested treatments, organic fertilized soil mixed with pineapple leaf produced the tallest and most vigorous seedlings, while organic fertilized soil alone and soil blended with cocopeat residues resulted in comparatively lower growth performance. However, the height among the three mixtures did not show a significant difference. Therefore, all three mixtures are equally suitable to be used as planting media. These results confirm the first objective of the study, which was to identify the most suitable soil composition for seedling development, and address the second objective by establishing clear growth differences across treatments.

In contrast, sample 2 with 70% of soil and 30% of cocopeat showed moderate improvement in plant growth relative to the control treatment. Cocopeat is well known for its high-water holding capacity and ability to enhance soil porosity, however, its relatively low nutrient content may have limited its effectiveness when compared to pineapple leaf amendment. As a result, although cocopeat improved the physical properties of the soil, it may not have provided sufficient nutrients to support more vigorous early growth [13].

Sample 1 with 100% soil consistently exhibited the lowest growth rate, suggesting that unamended soil alone was less capable of supporting optimal early-stage plant growth. This may be due to poorer aeration, lower organic matter content and limited nutrient availability compared to soils supplemented with organic materials. These findings highlight the importance of organic amendments in improving soil quality and promoting plant growth.

The growth differences observed among the three observations as illustrated in Figure 3. Overall, the results suggest that pineapple leaf amendments have greater potential than cocopeat in improving early plant growth., making it a promising and sustainable alternative growth medium for *Brassica rapa* cultivation.

Despite these limitations, this study contributes valuable comparative evidence regarding soil mixture performance for *Brassica rapa* seedlings. It reinforces the effectiveness of cocopeat as a soil amendment, highlights the need for further refinement in the use of pineapple leaf residues, and provides a practical basis for developing affordable and sustainable planting media tailored for smallholder and urban agriculture contexts.

6. CONCLUSION

Based on this study, the composition of the soil mixture composition is crucial to the early the early-stage growth of *Brassica rapa* seedlings. While soil alone and soil with cocopeat residues performed relatively poorly, the combination of organic fertilised soil and pineapple leaf consistently produced the tallest and most vigorous seedlings among the tested treatments. These results highlight the potential of pineapple leaf as an efficient and sustainable amendment to improve seedlings growth, especially in urban and small-scale agriculture where locally accessible and reasonably priced resources are crucial.

For future research, it is recommended to evaluate the long-term effects of these soil mixtures beyond the seedling stage, assess root system development, and investigate the potential of pre-treated pineapple leaf residues as a viable alternative medium. Expanding trials under real field conditions would also provide stronger evidence for practical applications.

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