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The Effect of Sugarcane Leaf Substrate on the Growth of Macadamia Integrifalia Seedlings

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Abstract

In order to select an alternative substrate formula to replace imported peat for Macadamia integrifalia seedlings, this study used sugarcane leaves as the primary material, supplemented with livestock and poultry manure, and employed a self-developed high-temperature aerobic fermentation technology. Through formula optimization, the effects of different ratios of sugarcane leaf substrates on the growth of Macadamia integrifalia seedlings was investigated. The results suggested that, except for T4, the treatments T1-T3 can effectively promote the growth of Macadamia integrifalia seedlings. Among them, the T2 treatment group had a significantly higher plant height growth rate than the control group (CK group), and the stem diameter growth rate of T2 was second only to that of CK group. Neverthess, the root growth of T2 was significantly better than that of CK group. Based on a comprehensive evaluation of the nutrient requirements and growth performance of Macadamia integrifalia seedlings, the T2 treatment, with a substrate ratio of V (sugarcane leaf-pig manure substrate): V (topsoil) = 1:5, was found to be the best substrate formula for cultivating Macadamia integrifalia seedlings.

Keywords

Macadamia integrifalia, seedling substrate, growth performance.

1. Introduction

Macadamia integrifalia is an evergreen fruit tree commonly grown in tropical and subtropical regions, which belongs to the Proteaceae family, and is also known as the Hawaiian nut [1]. China is the fastest-growing country in terms of the plantation area of Macadamia integrifalia and has now become the largest Macadamia integrifalia-producing country in the world.

The seedling substrate is a fundamental and critical factor in the cultivation of woody plants[4-6]. A suitable substrate plays a remarkable role in cultivating high-quality seedlings.

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Currently, peat-based substrates, widely used in nursery cultivation, have placed significant pressure on the ecological environment, making it urgent to find alternative materials [7]. With the rapid expansion of China's Macadamia integrifalia industry, the shortage and low compatibility of substrates have become key issues restricting the development of this industry[8]. Additionally, due to the long nursery cycle of Macadamia integrifalia, conventional seedling substrates generally only utilized topsoil. Subject to factors like soil fertility, the plants grow at a slow pace, causing Macadamia integrifalia seedlings to remain in a state of supply shortage, and the seedling prices stubbornly high, raising the planting costs for fruit farmers. Developing high-quality, low-cost seedling substrates suited to local conditions and improving the seedling quality of Macadamia integrifalia is of great importance for the high-quality development of the Macadamia integrifalia seedling substrate industry. It holds tremendous importance for improving the quality and efficiency of the Macadamia integrifalia industry, enhancing farmers' employment and income, and promoting the integrative development of primary, secondary, and tertiary industries in rural areas.

This paper utilizes sugarcane leaf waste from Southern China's hot regions as the primary raw material, supplemented with livestock and poultry manure, to create a cost-effective and high-performance Macadamia integrifolia seedling substrate through high-temperature aerobic fermentation technology. It examines the substrate's impact on the growth of Macadamia integrifolia seedlings, aiming to identify a formula that can replace imported peat for Macadamia integrifalia seedlings. The cultivation effects are assessed to lay the groundwork for further optimization and finalization of the substrate formula and production process. This also helps fully leverage the advantages of biomass resources, contributing to enhanced quality and efficiency of the cyclic development of green ecology in agriculture.

2. Materials and methods

2.1. Experimental materials

(1) Macadamia integrifalia seedlings

3-4 months old Macadamia integrifalia seedlings with consistent growth (about 20-30 cm in height) were taken for the non-woven fabric bag cultivation experiment.

(2) Sugarcane leaf-based substrate

Using a self-developed high-temperature aerobic fermentation technology, the sugarcane leaves were ground and mixed with pig manure and cow manure at a dry matter ratio of 5:1, respectively. The mixture was then aerobically fermented in $1m^3$ ton bags according to the optimal fermentation process, prepared into sugarcane leaf-pig manure and sugarcane leaf-cow manure substrates and reserved as raw materials.

2.2. Experimental grouping

(1) Experimental grouping

The experiment was carried out at a Macadamia integrifalia seedling base of the South Subtropical Crops Research Institute, Chinese Academy of Tropical Agricultural Sciences, located in Zhanjiang City, Guangdong Province (longitude 110°24′E, latitude 21°12′N). The experiment included five treatments, in which topsoil was mixed with sugarcane leaf-pig

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manure substrate, and sugarcane leaf-cow manure substrate respectively in specific volume ratios to create different substrate formulas. These formulas were then placed in non-woven fabric nursery bags for standby. The control group (CK) employed a premium formula selected by experts at the base. The detailed experimental design is shown in Table 1.

Table 1: Raw materials, ratios and grouping of the substrates

Treatment Group	Raw Material	Ratio
T1	Pig manure + sugarcane leaves: topsoil	1:10
T2	Pig manure + sugarcane leaves: topsoil	1:5
T3	Cow manure + sugarcane leaves: topsoil	1:10
T4	Cow manure + sugarcane leaves: topsoil	1:5
T5	Biogas residue + coconut leaves: topsoil	1:5
CK group	Commercially available organic fertilizer: peat: topsoil	1:0.5:20

Non-woven fabric bag cultivation (specifications: 16 cm × 20 cm) was used, with the bags with seedlings arranged in neat rows, 6 bags per row on the seedbed. Healthy Macadamia integrifolia seedlings with consistent growth were selected and planted at the center of the nursery bags filled with substrate. Each bag contained one seedling, with three repetitions per treatment, each having 10 seedlings, totaling 30 seedlings. The repetitions were arranged randomly and neatly, with sufficient water applied to promote root establishment. Throughout the experiment, all treatments adhered to the same cultivation management practices.

2.3. Measurement method

A sufficient amount of substrate soil was collected from each treatment's nursery bags to measure nutrient content in the soil. Specifically, the soil alkali-hydrolyzable nitrogen content was determined using the alkaline hydrolysis diffusion method; the soil available phosphorus content was determined by extracting with 0.5 mol/L NaHCO3 and using the molybdenum-antimony anti-colorimetric method; the soil available potassium content was determined by extracting with 1.0 mol/L ammonium acetate and using the flame photometry method. The moisture content was measured by the drying method at 105 ° C, and the electrical conductivity was measured with a portable rapid conductivity meter [9].

On days 1, 60, 120, 180, and 240 after planting the seedlings, the plant height and stem diameter (measured 2 cm above the substrate surface in the nursery bags) of the Macadamia integrifalia seedlings were measured using a ruler and vernier caliper. Additonally, on days 60, 120, 180, and 240, the chlorophyll content and nitrogen content in the mature leaves of the seedlings at the 4th to 5th leaf position from the tender apex were measured using a chlorophyll analyzer, with one seedling randomly selected from each treatment.

2.4. Data analysis

Data processing, variance analysis and correlation analysis were carried out using Excel 2007 and SPSS 17.0 software.

3. Experimental results

3.1. Effect of substrate nutrients on the growth performance of Macadamia integrifalia seedlings

As can be seen from Table 2, there were significant differences in the contents of available phosphorus, rapidly available potassium and alkali-hydrolyzable nitrogen in different substrate formulas. For rapidly available potassium, the content in the treatments T1-T3 were significantly lower than that in CK group, while T4 had a similar content to CK group. In terms of available phosphorus, the content in T4 was significantly higher than that in CK group, with values of 257.38 mg/kg and 770.12 mg/kg, respectively. For alkali-hydrolyzable nitrogen, the content in CK group was significantly higher than the other four treatments, with T1 showing the lowest content, only 79.1 mg/kg.

The nutrients required for the growth of container seedlings were entirely derived from the seedling substrate. The nutrient content and physical properties, etc. of the seedling substrate played a key role in the growth and development of container seedlings [10-12]. Research has indicated that, except for T4, which was affected by diseases, the stem diameter growth rate of Macadamia integrifalia seedlings showed a significant positive correlation with the nitrogen content in the substrate. The plant height growth rate also showed a positive correlation trend with the nitrogen content in the substrate (Figs. 1 and 2).

Table 2: Nutrient content of the substrates before cultivation

Group	Moisture Content (%)	Rapidly Available Potassium (mg/kg)	Available Phosphorus (mg/kg)	Alkali-hydrolyzable Nitrogen (mg/kg)	Electrical Conductivity (ms/cm)
T1	28.51	284.89	1.87	79.1	0.123
T2	25.41	434.83	28.86	144.14	0.222
T3	27.56	520	89.53	119.71	0.222
T4	33.49	1159.54	257.38	156.53	0.428
T5	26.77	579.07	770.12	150.2	0.337
CK	29.51	1239.01	153.6	420.34	3.17

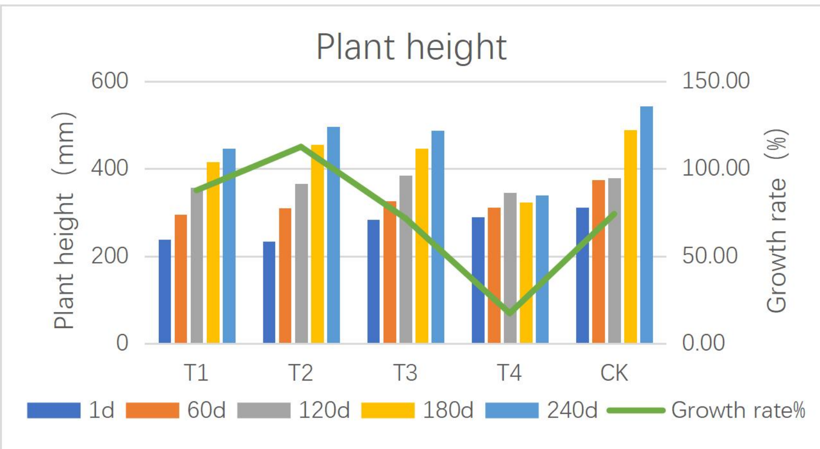

Figure 3: Changes in plant height and its growth rate

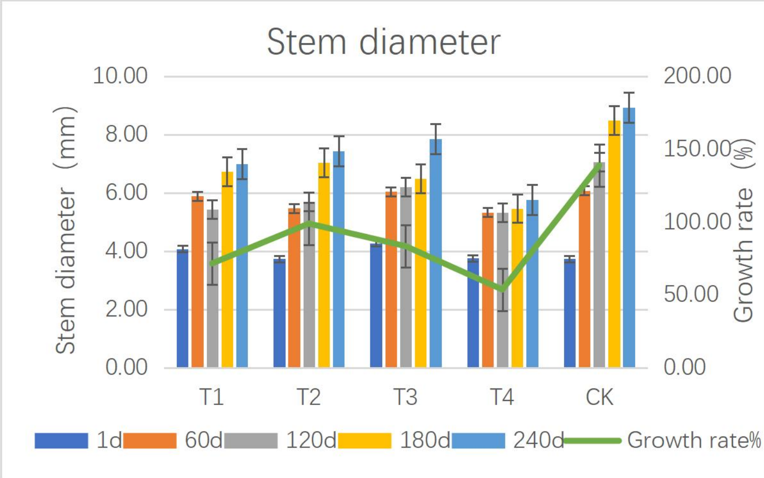

Figure 4: Changes in stem diameter and its growth rate

3.2. Effect of sugarcane leaf substrate on the chlorophyll content and nitrogen content in Macadamia integrifalia leaves

In the present study, the trends in nitrogen content and chlorophyll content were generally uniform. There were no significant differences in chlorophyll content and nitrogen content among T1-T3 and T5 groups and the seedling growth was favorable. However, the T4 treatment group had the lowest chlorophyll content and nitrogen content. The poor overall growth of T4 was likely due to disease infection in the sampled plants during later growth stages, affecting the accuracy of the experimental results for this group.

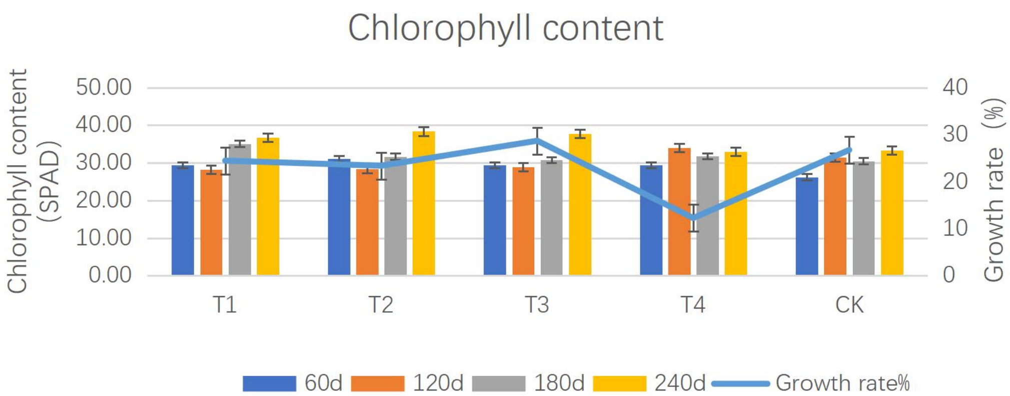

Figure 5: Changes in chlorophyll content and its growth rate

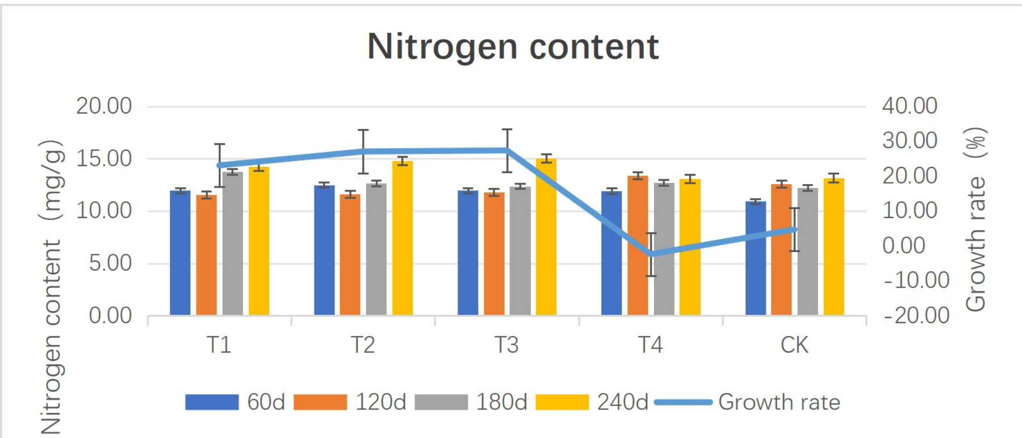

Figure 6: Changes in nitrogen content in leaves and its growth rate

3.3. Effect of Sugarcane Leaf Substrate on the Root System of Macadamia Integrifalia

Seedling substrates can provide an optimal air and water space for the root system of woody plants, which is fundamental for healthy root growth. The granular structure of the substrate helps increase the contact area between the root system and the substrate, improving root attachment and stability, thereby benefiting the extension and development of the root system. The root growth conditions of different groups offer a clear visual representation. The roots of T2, T3 and T5 were better developed than those of the CK group, with T2 particularly exhibiting well-developed roots, featuring a deep and long main root and dense fibrous roots, indicating robust growth.

Figure 7: Effect of different substrates on the root growth of Macadamia integrifalia seedlings (from left to right: T1-T4, CK)

4. Conclusion

Taken together, except for T4, the treatments T1-T3 can effectively promote the growth of Macadamia integrifalia seedlings. Among them, the plant height growth rate in the T2 group was significantly better than that of the CK group, while the stem diameter growth rate of T2 was second only to CK group. Besides, the root growth of T2 was significantly better than that of CK group. This suggests that using sugarcane leaves supplemented with livestock and poultry manure as a substitute for imported peat holds promising application prospects, though there remains considerable room for further exploration. In this study, a comprehensive evaluation was conducted based on the nutrient requirements and growth performance of Macadamia integrifolia seedlings. The results indicated that the T2 treatment, with a substrate ratio of V (sugarcane leaf-pig manure substrate): V (topsoil) = 1:5, was the optimal substrate mix for cultivating Macadamia integrifolia seedlings.

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References

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[1] L.Q. Du, M.H. Zou, H. Zeng, et al. Analysis of the nutrient composition of macadamia nut. Acta Nutrimenta Sinica, 2010, 32(1): 95-96.

[2] J.W. Ai, G.D. Liu, X.X. Huang, et al. Analysis of current situation and development trend regarding macadamia nut industry. The Food Industry, 2018, 39(11): 282-285.

[3] X.Y. He, L. Tao, J. Liu, et al. Overview of macadamia industry and its development trend in China. Tropical Agricultural Science & Technology, 2015, 38(3): 12-16, 19.

[4] F. Teng, Y. Liu, J.W. Hu, et al. Effects of different mushroom slag compost on growth and nutrient accumulation of Pinus tabulaeformis containerized transplantings. Journal of Nanjing Forestry University (Natural Science Edition), 2016, 40(5): 184-190.

[5] Z.L. Ding, B.Z. Wang, Z.Q. Jin, et al. Effects of different coconut coir ratios on growth of Brazil banana. Acta Agriculturae Zhejiangensis, 2016, 28(5): 853-856.

[6] H.T. Liang, Z.J. He, X.B. Gao, et al. Influences of mushroom residue, peat and vermiculite matrix product on the growth characteristics of tomato seedlings. Acta Agriculturae Boreali-Sinica, 2015, 30(4): 194-199.

[7] R.J. Wei, H.J. Chi, W.H. Lian, Z. Liu, X.Y. Liu: Evaluation on the improvement of coconut coir substrate seedling effect by adding nutrients from different sources. Journal of Shanxi Agricultural University (Natural Science Edition), 2025, 45(01): 103-113.

[8] Y. Li, E.L. Li, Y.L. Mao, et al. Effects of growing media on seedling performance of melientha longistaminea. Journal of Northeast Forestry University, 2019, 47(3): 8-11, 21.

[9] L. Yang, C.F. Liang, Z.Y. Gu, et al. Effect of substrate proportion on the growth of container seedlings of Litsea cubeba. Journal of Central South University of Forestry & Technology, 2020, 40(10): 94-100.

[10] J. Wu, X.G. Li, S.Y. An. Effects of different substrate ratios on the growth of sour pummelo seedlings. Chinese Journal of Tropical Crops, 2018, 39(3): 443-447.

[11] Q.M. Shui, Q.L. Liu, J.R. Han, et al. Effects of different substrate ratios on the growth of sour pomelo seedlings. Agriculture & Technology, 2024, 44(22): 80-83.

[12] S.D. Huang, J. Lin, L. Huang, H.H. Tang: The influence of different substrate recipes on the growth of schima superba container seedlings. Protection Forest Science and Technology, 2024, (05): 71-74.

[13] J. Huang, H. Yao, X.L. Zhang, et al. The effect of substrate ratios on the growth and photosynthetic characteristics of Bougainvillea speetabilis. Chinese Agricultural Science Bulletin, 1-8 [2025-02-08]. http://kns.cnki.net/kcms/detail/11.1984.S.20241226.1714.002.html.

[14] Y.R. Xie, D. Tang, P. Zhang, et al. Effect of different substrate ratios on growth of pepper seedlings. Northern Horticulture, 2020(4): 7-14.

[15] T. Wang, J.G. Lei, Y.K. Chen, et al. Effect of substrates containing hypsizygus marmoreus discards on growth of lettuce. Fujian Journal of Agricultural Sciences, 2018, 33(10): 1043-1048.