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The Influence of NPK Fertilizer Doses and Growing Media on the Growth of Nutmeg Seedlings (*Myristica fragrans* Houtt)

Yuliatul Muslimah[1], Muhammad Afrillah[2], and Sumeinika Fitria Lizmah[3*]
[123]Department Agrotechnology, Faculty of Agriculture, Teuku Umar University, Meulaboh, Indonesia

***Corresponding Author:** sumeinikafitrializmah@utu.ac.id
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Abstract
Nutmeg nurseries are crucial for increasing production and ensuring the sustainability of nutmeg cultivation in South Aceh. Fertilizers and planting media are key factors for supporting healthy seedling growth. This study aims to explore the effects of NPK fertilizer and planting media on nutmeg seedling growth. The research was conducted at the University Farm, Teuku Umar University, from August to November 2024. The experiment used a Randomized Block Design (RBD) with two factors: fertilizer dosage (five levels: no fertilizer, 2.5 g, 5 g, 7.5 g, and 10 g per polybag) and planting media (four types: alluvial soil, alluvial soil with rice husk charcoal, alluvial soil with manure, and alluvial soil with sand). The growth parameters measured were seedling height, number of leaves, and stem diameter. Data were analyzed using Analysis of Variance (ANOVA), followed by a Tukey test if significant differences were found. The results showed that fertilizer dosage significantly affected plant height at 42 days after planting, with the best results at 5 g per polybag. The highest increase in leaf number at 28 and 56 days was seen with 7.5 g per polybag. The planting media also significantly influenced seedling height and leaf number, with the best results from a mix of soil and organic fertilizer. The best combination of fertilizer and planting media was 7.5 g of fertilizer with soil and rice husk charcoal.
Keywords: Fertilizer; Growing media; Nutmeg; *Myristica fragrans*

Introduction
Aceh Province remains the largest supplier of nutmeg in Indonesia, along with North Maluku Province, Maluku, North Sulawesi, and West Papua (Directorate General of Plantations, 2021). South Aceh Regency is known as the central area for nutmeg, dominating 80.96% of the total nutmeg production in Aceh Province (Center for Agricultural Data and Information Systems, 2022). However, the productivity of nutmeg in Aceh Province, particularly in South Aceh Regency, is still relatively low due to poor plant management, one of which is the quality of the seedlings (Ramadhaini et al., 2014).

Nutmeg nurseries in South Aceh are generally from seeds, and 50.66% of farmers do not fertilize either during the nursery stage or for mature plants (Muslimah et al.,, 2024). This affects the low quality of the seedlings, which in turn impacts production. Good nutmeg seedlings, whether from seeds or grafting, need nutrients

to grow well. Fertilization as an effort to add nutrients to plants needs to be carried out to ensure nutritional needs are met. Nutrition is a crucial element that is essential for plants for their growth and development to realize the potential of maximum harvest yields and achieve higher economic value (Vaidehi et al., 2017). The provision of balanced nutrients and the completeness of macro and micronutrients are essential for plants (Ismail et al., 2024).

Besides fertilizers, the growing medium also plays an important role in the growth of nutmeg seedlings. The nursery media usually consists of a mixture of soil and organic matter in a specific ratio. The growth environment for optimal root development is a growing medium that provides optimal air, water, and nutrient needs (Maulana, 2016). The structure of the planting medium must have a good balance of air and water porosity, which determines the root growth of seedlings in polybags (Erwiyono, 2005).

The selection and provision of suitable planting media are useful for creating good environmental conditions and supplying the water and nutrients needed by the seeds during the germination and seedling growth processes (Arianto et al., 2018). Based on Manullang dan Silalahi (2019), the mixture of topsoil, rice husk ash, and manure significantly affects the height of the plants, the number of leaves, and the diameter of the nutmeg seedlings. Tony et al., (2015) explained that the composition of the planting media of soil, sand, and bokashi cow manure gives the best results for the growth of nutmeg seedlings.

The objective of this research is to obtain the best combination of fertilization levels and growing media composition in the growth of nutmeg plant seedlings. The research results can contribute to improving nutmeg cultivation techniques, particularly nutmeg seedling propagation, in South Aceh.

Research Method

Place and time of research

This research was conducted at the University Farm (UF) garden of Teuku Umar University in Alue Peunyareng, Meureubo District, West Aceh Regency. Plant analysis was conducted in the laboratory of PT. Socfindo Kebun Bangun Bandar, North Sumatera. The implementation of this research began in August – November 2024.

Materials and tools

The materials used in this research are 6-month-old nutmeg plant seedlings, Urea fertilizer, SP36 fertilizer, KCL fertilizer, Top Soil, manure, rice husk charcoal, polybags, brown envelopes, name labels, pamphlet wood, raffia string, bamboo, and paranet. Meanwhile, the tools used in this research are hoes, watering cans, soil augers, shovels, calipers, buckets, hand sprayers, utility knives, pruning shears, beakers,

ovens, analytical balances, measuring tapes, nylon ropes, stationery, and other tools that support this research.

Experimental design

The experimental design used in the research is a randomized block design (RBD) with a 5 x 4 factorial pattern. The factors studied include the recommended fertilization dosage and the composition of the planting media as follows. The first factor is the NPK fertilizer dosage, which consists of 5 treatment levels as follows P0: Without fertilizer application, P1: 2.5 g/polybag, P2: 5 g/polybag, P3: 7.5 g/polybag, and P4: 10 g/polybag. The second factor is the composition of the growing media, which consists of 4 types of treatments as follows M0: alluvial soil, M1: alluvial soil + rice husk charcoal (1:1), M2: alluvial soil + manure (1:1), M3: alluvial soil + sand (1:1).

Procedure of research

Land preparation and shade construction

The experimental land is first cleared for the placement of polybags from remnants of plant roots and weeds using a hoe. The construction of a 20 cm deep drainage system in the research area prevents water pooling. Then the soil in the area was leveled so that the placement of polybags would be orderly. After clearing the land and leveling the soil, a shade was constructed using paranet with bamboo poles.

Preparation of planting media

The media used are topsoil, rice husk charcoal, cow manure, and sand. According to the treatment, it is then sieved with a sieve until it becomes fine grains and free from remnants of waste and wild plant roots. Then the media is filled into 25x20 cm polybags according to the treatment, and then arranged according to the experimental diagram.

Planting seedlings

The seedlings are placed into the planting holes after the small polybags are removed. The soil around the hole is compacted evenly, and then additional soil is added up to the root collar.

Plant maintenance

Watering is done manually using a watering can. Watering is done twice daily. (morning and afternoon).

Fertilization

NPK fertilization is carried out according to the treatment levels. Fertilization is carried out by scattering it around the nutmeg seedling's root system. In this study,

fertilization is done until the seedlings are 4 months old after transplanting or 10 months old. Weeding is done in two ways, namely manually for polybags or using a hoe in the nursery area, with the weeding interval adjusted according to the condition of the weeds in the nursery.

Pest and disease control

Pest and disease control is carried out if the symptoms be discovered, by using Sevin 85 SP and Dithane M-45.

Observation parameters

The observation parameters conducted are the growth of nutmeg seedlings, which consist of the increase in seedling height (cm), number of leaves (leaves), increase in stem diameter (mm), root volume (ml), fresh weight of the canopy (g), dry weight of the canopy (g), fresh weight of the roots (g), dry weight of the roots (g), as well as plant tissue analysis in the form of N, P, and K nutrient content in the plant and growing medium. The research data was then processed using ANOVA analysis and the LSD at a 5% significance level using Excel and MINITAB applications.

Results and Discussion

Plant height increase

The results of the statistical analysis show that in the parameter of plant height increase of nutmeg seedlings, the fertilizer dosage factor has a significant effect at 42 days after planting (DAP), and the planting media factor has a significant effect at 28 and 42 DAP. There is no significant interaction between the two treatments tested. The average height increase of nutmeg seedling plants can be seen in Table 1.

Observation of the height growth parameters of nutmeg seedlings (Table 1) shows that the NPK fertilization dose of 5g/polybag (P2) has the highest yield trend and the lowest in the treatment without fertilization (P0), which is statistically significantly different at 42 days after planting (DAP). It is suspected that the application of the NPK fertilizer dose of 5g/polybag provides sufficient available nutrients, particularly phosphorus, potassium, and especially nitrogen, thereby increasing the height growth of the nutmeg seedlings. Each nutrient contained in this fertilizer has a different function, such as Nitrogen (N) which plays an important role in vegetative growth, especially in the formation of leaves and stems, directly contributing to the increase in seedling height (Syafar and Mattone, 2024). Phosphorus (P) supports root development and the early growth of seedlings, helps with optimal water and nutrient absorption, and encourages the overall height growth of seedlings (Amtmann et al., 2005). Potassium (K) plays an important role in the translocation of carbohydrates produced from photosynthesis to all parts of the plant, including the stem. This promotes the height growth of the plant, as carbohydrates are essential for the formation of new tissues in the shoots and stems (Hasanuzzaman et al., 2018).

The results of the research by Sari et al. (2023) showed that the application of the correct NPK dosage during the seedling phase significantly increases plant height growth, as this fertilizer provides the essential nutrients needed for early vegetative growth. The application of the correct NPK fertilizer dosage greatly affects the height increase of nutmeg seedlings (Wattimena, 2018). A dose that is too low can cause stunted growth due to a lack of necessary nutrients, while a dose that is too high can cause toxicity or nutrient imbalances in the soil. The application of the correct dosage of a combination of nutrients between nitrogen, phosphorus, and potassium ensures that every aspect of seedling growth, from root development to stem and leaf growth, proceeds optimally (Yahaya et al., 2023).

Table 1. Increase in height of nutmeg seedling plants under fertilizer dosage and planting media treatments

Age of plant	Treatment	Planting media				Average
	Fertilizer dosage	M0	M1	M2	M3	
28 DAP	P0	0,70	1,26	2,49	0,92	1,34
	P1	1,66	1,68	2,73	1,63	1,93
	P2	1,36	1,90	2,81	1,38	1,86
	P3	1,89	1,79	2,24	1,77	1,92
	P4	1,16	1,14	2,33	1,24	1,47
	Average	1,35b	1,55b	2,52a	1,39b	
42 DAP	P0	1,18	1,86	2,17	1,16	1,59b
	P1	2,50	2,37	2,78	1,71	2,34ab
	P2	1,98	2,12	3,32	2,62	2,51a
	P3	2,21	2,90	2,56	1,90	2,39ab
	P4	1,73	1,38	2,73	1,46	1,83ab
	Average	1,92b	2,12ab	2,71a	1,77b	
56 DAP	P0	1,19	1,66	1,66	1,03	1,38
	P1	2,14	1,77	2,28	1,59	1,94
	P2	2,10	1,91	1,88	2,02	1,98
	P3	1,74	2,07	1,61	1,64	1,77
	P4	1,74	1,94	2,28	1,29	1,81
	Average	1,78	1,87	1,94	1,52	

Note: Numbers followed by the same notation in the same column indicate no significant difference according to the Tukey Test at the 5% level.

Balanced NPK application increases fertilization efficiency and supports more uniform and faster seedling height growth. The treatment of planting media, soil composition + manure (M2) yielded the best results at 28 and 42 days after planting (DAP), significantly different statistically from other treatments in the parameter of seedling height increase of nutmeg plants (Tabel 1). It is suspected that the use of a

mixture of manure as a planting medium provides better physical, chemical, and biological properties for the growth of nutmeg seedlings. The physical and chemical properties of the growing medium, such as soil pH, water retention capacity, and nutrient content, affect the height growth of plant seedlings (Gofar et al., 2021).

Growing media with a pH that is too low or too high can hinder nutrient absorption by the roots. Growing media with good water retention capacity but not overly saturated can support the height growth of seedlings (Bunt, 2012). Balanced physical and chemical properties of the soil help create an ideal environment for the growth of nutmeg seedlings.

Growing media plays an important role in supporting the high growth of nutmeg plant seedlings because it affects the seedlings' ability to absorb water and nutrients. The ideal growing media should have good porosity to support root aeration, as well as the ability to optimally retain water and nutrients (Deepagoda et al., 2013). A good planting media combination for nutmeg seedlings usually consists of a mixture of soil and manure in a specific ratio. This planting medium is capable of providing sufficient nutrients and facilitating healthy root growth, thereby promoting height increase in nutmeg seedlings.

The use of organic planting media, such as manure, compost, or a mixture of leaf litter, contributes to height growth (Sayara et al., 2020). Organic matter provides essential nutrients gradually and increases the cation exchange capacity (CEC) of the soil, allowing seedlings to absorb more nutrients needed for growth (Suntari et al., 2021). In addition, organic media improve soil structure and support root growth, which directly affects the height increase of nutmeg seedlings.

Several research findings indicate that the combination of the right NPK dosage with a planting medium of soil and manure improves fertilizer use efficiency and yields better results in the height growth of nutmeg seedlings (Wattimena, 2018; Suryadi, 2017). Manure contains organic matter that enhances soil aeration and structure, allowing roots to absorb NPK fertilizer more effectively (Assefa and Tadesse, 2019).

Increase in number of leaves

The results of the statistical analysis show that the fertilizer dose treatment significantly affects the leaf number parameter at 28 and 56 days after planting (DAP), while the planting media factor significantly affects the age of 28 DAP. There is also an interaction between the two treatments that shows significant results at 28 and 56 DAP. The NPK fertilization dose of 7.5g/polybag (P3) has the highest yield tendency, while the lowest yield is observed in the treatment without fertilization (P0), which is statistically significantly different at 28 and 56 days after planting (DAP) (Table 2).

Based on the observations, it is suspected that the NPK dose of 7.5g/polybag provides optimal nutrients such as nitrogen, phosphorus, and potassium for cell development in plants, which affects the vegetative growth of nutmeg seedlings. Each nutrient content in the NPK fertilizer plays an important role in the growth of nutmeg plants.

Table 2. Increase in leaf of nutmeg seedling plants under fertilizer dosage and planting media treatments

Age of plant	Treatment	Planting media				Average
	Fertilizer dosage	M0	M1	M2	M3	
28 DAP	P0	1,00ab	0,67c	1,67ab	0,89ab	1,06b
	P1	1,33ab	1,78ab	2,22a	1,11ab	1,61a
	P2	1,22ab	0,78bc	2,11ab	0,78bc	1,22ab
	P3	1,56ab	1,56ab	1,78ab	1,67ab	1,64a
	P4	1,33ab	0,78bc	2,11ab	0,89ab	1,28ab
	Average	1,29b	1,11b	1,98a	1,07b	
42 DAP	P0	2,11	1,89	1,33	0,89	1,56
	P1	1,33	1,78	2,00	2,22	1,83
	P2	1,67	1,44	1,89	2,00	1,75
	P3	1,00	2,67	2,11	2,22	2,00
	P4	1,33	1,56	3,00	1,11	1,75
	Average	1,49	1,87	2,07	1,69	
56 DAP	P0	1,11b	1,00b	2,00ab	0,67b	1,19b
	P1	2,44ab	2,22ab	2,11ab	2,56ab	2,33a
	P2	2,00ab	2,78ab	2,78ab	1,33b	2,22a
	P3	1,56ab	4,11a	2,11ab	3,00ab	2,69a
	P4	1,67ab	2,33ab	3,11ab	1,22b	2,08ab
	Average	1,76	2,49	2,42	1,76	

Note: Numbers followed by the same notation in the same column indicate no significant difference according to the Tukey Test at the 5% level.

Nitrogen (N) is a macro nutrient that is very important for plants, especially in supporting vegetative growth, including the number of leaves. Nitrogen functions as a component of living cells because it is present in all parts of the plant and as a constituent of enzymes and chlorophyll molecules (Hakim et al., 1986). Nitrogen plays a role in the formation of chlorophyll, which is necessary for the photosynthesis process. In nutmeg plants, adequate nitrogen supply will increase leaf production, as healthy and abundant leaves accelerate the photosynthesis process, thereby optimizing the vegetative growth of the plant (Anas et al., 2020).

Phosphorus (P) plays an important role in root formation and energy transfer within plants, which ultimately affects leaf growth. Phosphorus helps improve the efficiency of water and nutrient absorption, thereby supporting the growth of

vegetative organs Chen et al., 2020). In addition to nitrogen and phosphorus nutrients in NPK fertilizer, there is potassium (K), which plays a role in regulating water within plant cells and strengthening plant tissues, including leaf tissues. Potassium helps maintain the water balance in the leaves, keeping them healthy, dark green, and more resistant to pests and diseases (Rawat et al., 2016). The application of the correct potassium dosage affects the increase in the number of leaves on nutmeg plants, because potassium enhances the efficiency of water and nutrient use, and improves leaf quality, making the plants more productive in producing new leaves.

The treatment of planting media, soil composition + manure (M2) yielded the best results at 28 DAP, which were statistically significantly different from other treatments in terms of the increase in the number of leaves (Tabel 2). This is suspected to be due to the application of manure in the mixing of planting media, which provides additional nutrients, both macro and micro, as well as improving the physical properties of the soil that support the vegetative growth of nutmeg seedlings.

The planting media, consisting of a mixture of soil and manure, has been proven to significantly increase the number of leaves on the plants. Manure as a source of organic material provides the macro and micronutrients needed by plants, such as nitrogen, phosphorus, and potassium, and also improves the physical structure of the soil. This helps improve aeration, increase water retention, and accelerate nutrient absorption by plant roots (Nurhayati and Yusof, 2022).

The mixture of soil with manure produces a greater number of leaves on the plants compared to the medium that only uses pure soil. Manure enriches the media with organic nutrients, increases the activity of microorganisms in the soil, and supports the growth of new leaves. Manure contains organic nitrogen that is released gradually, providing plants with stable nutrients to support vegetative growth Sindhu et al., 2020). The use of manure also increases the cation exchange capacity (CEC) of the soil, making other nutrients like phosphorus and potassium more available to plants.

Organic materials from manure function as a nutrient buffer that helps maintain soil moisture and provides essential nutrients for nutmeg plants. Manure increases soil fertility by enhancing the organic matter content and essential nutrients, such as nitrogen, which are needed for leaf growth (Rachmadtullah et al., 2024). The planting medium containing 50% soil and 50% manure has been tested to accelerate the increase in the number of leaves on nutmeg seedlings, because the nutrients in the manure are absorbed more efficiently by the roots, resulting in better leaf growth.

The combination of a 7.5g fertilizer dose treatment + a planting medium of soil and rice husk charcoal (P3M1) shows the highest tendency for increased leaf number in nutmeg seedlings at 56 days after planting (DAP). The combination of inorganic

fertilizer (NPK) and organic materials such as rice husk charcoal in the planting medium can enhance fertilizer use efficiency and accelerate the growth of nutmeg leaves. Growing media mixed with organic materials helps improve soil structure and increase cation exchange capacity, making it easier for added inorganic fertilizers to be absorbed by the roots (Bamdad et al., 2022).

The application of optimal NPK doses with a planting medium containing rice husk charcoal can accelerate the increase in the number of nutmeg plant leaves. Providing NPK in appropriate amounts supplies essential nutrients, especially nitrogen, which is needed for leaf formation (Das and Avasthe, 2018). Meanwhile, rice husk charcoal maintains soil moisture stability and provides more space for roots to grow. Research shows that the use of a combination of growing media, such as soil and rice husk, yields the best results in enhancing growth. This combination provides a balance between aeration, moisture, and nutrient availability. Rice husk increases the porosity of the media and supplies nutrients from organic matter, while soil provides mechanical support for the roots to grow stronger (Pratiwi and Shinogi, 2016).

Increase in stem diameter

The results of the statistical analysis show that in the parameter of stem diameter increase, the treatment of fertilizer dosage and planting media, as well as the interaction between the two treatments, did not show significant results at 28, 42, and 56 days after planting (DAP). The research results on the parameter of stem diameter increase in nutmeg seedlings (Table 3) indicate that the NPK fertilizer dosage of 5g/polybag (P3) has the highest tendency for results and the lowest in the treatment without fertilization (P0), although there is no significant statistical difference at 56 DAP. The growth of plants during the vegetative phase is a crucial early stage for the survival and long-term productivity of the plants. At this phase, plants require an optimal supply of nutrients to build vegetative organs such as leaves, roots, and stems (Leghari et al., 2016). One of the main aspects of vegetative growth that is important to pay attention to is the stem diameter. A strong and sturdy stem is crucial for a plant's ability to support leaves, flowers, and fruits, as well as to transport water and nutrients from the roots to all parts of the plant.

Table 3. Increase in stem diameter of nutmeg seedling plants under fertilizer dosage and planting media treatments

Age of plant	Treatment	Planting media				Average
	Fertilizer dosage	M0	M1	M2	M3	
28 DAP	P0	1,20	1,53	1,20	1,23	1,29
	P1	1,43	1,16	1,13	1,40	1,28
	P2	1,24	1,08	1,12	1,18	1,16

	P3	1,27	1,27	1,61	1,49	1,41
	P4	1,12	0,93	1,53	1,36	1,24
	Average	1,25	1,19	1,32	1,33	
42 DAP	P0	0,50	0,54	0,57	0,48	0,52
	P1	0,58	0,70	0,37	0,36	0,50
	P2	0,62	0,58	0,59	0,44	0,56
	P3	0,41	0,79	0,40	0,53	0,53
	P4	0,82	0,63	0,51	0,74	0,68
	Average	0,59	0,65	0,49	0,51	
56 DAP	P0	0,41	0,31	0,56	0,41	0,42
	P1	0,37	0,44	0,57	0,42	0,45
	P2	0,38	0,37	0,54	0,79	0,52
	P3	0,44	0,50	0,40	0,39	0,43
	P4	0,56	0,43	0,43	0,32	0,44
	Average	0,43	0,41	0,50	0,47	

The treatment of planting media, soil composition + manure (M2) showed a tendency for the best results at 56 DAP, although it was not statistically different from other treatments in the parameter of stem diameter increase in nutmeg seedlings (Tabel 3). Manure contains various macro and micro nutrients that are highly needed by plants, such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and other micro elements (Hapsari and Chalimah, 2013). This nutrient is important to support cell division and the enlargement of stem tissue, so the diameter of the plant stem can develop optimally.

In addition to the main nutrients, manure also contains microelements such as iron (Fe), zinc (Zn), manganese (Mn), and boron (B) that support the formation of new tissues and enzymatic activity within the plant (Rayne and Aula, 2020). This combination of nutrients plays an important role in the physiological processes of plants that support the increase in stem diameter. Manure also contains natural microorganisms such as bacteria, fungi, and actinomycetes that play a role in the decomposition of organic matter and enhance nutrient availability in the soil (Singh et al., 2020). These microorganisms help break down organic compounds into forms of nutrients that are more easily absorbed by plant roots. With better nutrient availability, the process of stem tissue formation proceeds more quickly and efficiently. Microorganisms in manure also produce growth regulators such as auxin, cytokinin, and gibberellin, which help accelerate cell division and tissue enlargement in stems (Wong et al., 2015). Auxin, for example, plays a significant role in the process of cell elongation, while cytokinin and gibberellin support cell division and differentiation.

Conclussion

Fertilizer dosage significantly affects the increase in plant height at 42 HST with the best dosage of 5 gr/polybag (P2), while the highest increase in the number of leaves at 28 and 56 HST was treated with a dosage of 7.5gr/polybag (P3). Planting media significantly affects the increase in the height of nutmeg seedlings at 28 and 42 HST and the increase in the number of leaves at 28 HST, with the best planting media being the composition of soil + organic fertilizer (M2). The best combination of fertilizer and planting media is found in the treatment of a fertilizer dosage of 7.5gr + a mixture of soil and rice husk charcoal planting media (P3M1).

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References

Amtmann, A., Hammond, J.P., Armengaud, P., and White, P.J. (2005). Nutrient sensing and signalling in plants: potassium and phosphorus. *Advances in botanical research*, *43*:209-257.

Anas, M., Liao, F., Verma, K.K., Sarwar, M.A., Mahmood, A., Chen, Z.L., and Li, Y.R. (2020). Fate of nitrogen in agriculture and environment: agronomic, eco-physiological and molecular approaches to improve nitrogen use efficiency. *Biological research*, 53:1-20.

Arianto, A., Basri, Z., and Wahyudi, I. (2018). Pengaruh pemberian giberelin dan berbagai media tanam terhadap perkecambahan dan pertumbuhan benih pala (*Myristica fragrans* Houtt). *Mitra Sains*, 6(1):1-12.

Assefa, S., and Tadesse, S. (2019). The principal role of organic fertilizer on soil properties and agricultural productivity-a review. *Agri Res and Tech: Open Access J*, 22(2):556192.

Bamdad, H., Papari, S., Lazarovits, G., and Berruti, F. (2022). Soil amendments for sustainable agriculture: Microbial organic fertilizers. *Soil Use and Management*, 38(1):94-120.

Bunt, A.C. (2012). *Modern Potting Composts: A Manual on The Preparation and Use of Growing Media for Pot Plants.* Springer Science & Business Media.

Center for Agricultural Data and Information Systems. (2022). Outlook for Nutmeg Plantation Commodities. Secretariat General-Ministry of Agriculture, Jakarta

Chen, Z., Khan, A., Shi, X., Hao, X., Tan, D.K.Y., and Luo, H. (2020). Water-nutrient management enhances root morpho-physiological functioning, phosphorus absorption, transportation and utilization of cotton in arid region, *Industrial Crops and Products*, 143:111975.

Das, S.K., and Avasthe, R. (2018). Plant nutrition management strategy: a policy for optimum yield. *Acta Scientific Agriculture*, 2(5).

Deepagoda, T.C., Lopez, J.C.C., Møldrup, P., de Jonge, L.W., and Tuller, M. (2013). Integral parameters for characterizing water, energy, and aeration properties of soilless plant growth media. *Journal of Hydrology*, *502*:120-127.

Directorate General of Plantations. (2021). Indonesian Plantation Statistics for Nutmeg Commodity 2020-2022, Directorate General of Plantations. Ministry of Agriculture of the Republic of Indonesia, Jakarta.

Erwiyono, R. (2005). Alasan Penambahan Pupuk Kandang dan Pasir pada Media Tanam di Pembibitan. Waplusit Kopi dan Kakao. Jember.

Gofar, N., Permatasari, S.D.I., and Setiawati, P. (2021). *Pengantar Bercocok Tanam Agroekologis*. Bening Media Publishing.

Hakim, N., Nyakpa, M.Y., Lubis, A.M., Nugroho, S.G. (1986). *Dasar Ilmu Tanah*, Universitas Lampung.

Hapsari, A.Y., and Chalimah, S. (2013). Kualitas dan kuantitas kandungan pupuk organik limbah serasah dengan inokulum kotoran sapi secara semi anaerob, Doctoral Dissertation, Universitas Muhammadiyah Surakarta.

Hasanuzzaman, M., Bhuyan, M.B., Nahar, K., Hossain, M.S., Mahmud, J.A., Hossen, M.S., and Fujita, M. (2018). Potassium: a vital regulator of plant responses and tolerance to abiotic stresses. *Agronomy*, 8 (3):31.

Ismail, Syafar, A.R, and Mattone, A.A. (2024). Pengaruh dosis pupuk nitrogen dan fosfor terhadap pertumbuhan bibit pala. *Journal Agroecotech Indonesia (JAI),* 3(01) 44-52.

Leghari, S.J., Wahocho, N.A., Laghari, G.M., Laghari, A.H., Bhabhan, G.M., Talpur, H.K., and Lashari, A.A. (2016). Role of nitrogen for plant growth and development: A review. *Advances in Environmental Biology*, 10(9):209-219.

Maulana, F. (2016). Pengaruh Media Pembibitan dan Ukuran Kecambah Terhadap Pertumbuhan Bibit Pala (*Myristica fragrans* Houtt). IPB University.

Manullang, W., and Silalahi, F.R. (2019). Pengaruh komposisi media tanam terhadap pertumbuhan bibit kakao (*Theobroma cacao* L.). *Agrica Ekstensia*, 13 (2):28-34.

Muslimah, Y., Afrillah, M., Lizmah, S.F., Junita, D., and Harahap, E.J. (2024). Identification of cultivation management and abiotic components in people's nutmeg plantations in South Aceh Regency. *International Journal of Social Science, Educational, Economics, Agriculture Research, and Technology (IJSET),* Vol 3 No. 5.

Nurhayati, D.R. and Yusof, S.F.B. (2022). *Herbal dan rempah*. Scopindo Media Pustaka.

Pratiwi, E.P.A., and Shinog, Y. (2016). Rice husk biochar application to paddy soil and its effects on soil physical properties, plant growth, and methane emission. *Paddy and water environment*, 14:521-532.

Rachmadtullah, M.I., Yudanti, T.N.A., Harfani, S.D., Ula, M.A.N., and Sari, D.E. (2024). Peranan aplikasi pupuk organik terhadap perbaikan kualitas tanah untuk meningkatkan produktivitas pertanian. *Hibrida: Jurnal Pertanian, Peternakan, Perikanan,* 2(2):51-60.

Ramadhaini, R.F., Sudradjat, Wachjar, A. (2014). Optimasi dosis pupuk majemuk NPK dan Kalsium pada bibit kelapa sawit (*Elaeis guineensis* Jacq.) di pembibitan utama. *J. Agron. Indonesia,* Vol. 42(1). 52–58.

Rawat, J., Sanwal, P., and Saxena, J. (2016). Potassium and its role in sustainable agriculture. In Potassium solubilizing microorganisms for sustainable agriculture, New Delhi: *Springer India*, 235-253.

Rayne, N., and Aula, L. (2020). Livestock manure and the impacts on soil health: A review. *Soil Systems*, 4(4):64.

Sari, N.L., Sasmita, E.R., and Irawati, E.B. (2023). Application of NPK Fertilizer and Paclobutrazol on Growth. *In BIO Web of Conferences,* Vol. 69.

Sayara, T., Basheer-Salimia, R., Hawamde, F., and Sánchez, A. (2020). Recycling of organic wastes through composting: Process performance and compost application in agriculture. *Agronomy*, 10(11):1838.

Sindhu, V., Chatterjee, R., Santhoshkumar, G.M., and Sinha, T. (2020). Enrichment of organic manures and their utilization in vegetable crops. *Current Journal of Applied Science and Technology*, 39 (32):10-24.

Singh, T.B., Ali, A., Prasad, M., Yadav, A., Shrivastav, P., Goyal, D., and Dantu, P.K. (2020). Role of organic fertilizers in improving soil fertility. *Contaminants in agriculture: sources, impacts and management*, 61-77.

Suntari, R., Nugroho, G.A., Fitria, A.D., Nuklis, A., and Albarki, G.K. (2021). *Teknologi Pupuk dan Pemupukan Ramah Lingkungan.* Universitas Brawijaya Press.

Suryadi, R. (2017). Research strategy of cultivation to improve productivity and competitiveness of nutmeg. *Perspektif: Review Penelitian Tanaman Industri,* 16(1):1-13.

Syafar, A.R. and Mattone A.A. (2024). Pengaruh fertilizer dosage nitrogen dan fosfor terhadap pertumbuhan bibit pala. *Journal Agroecotech Indonesia (JAI)*, *3* (01):44-52.

Tony, T., Bahrudin, B., and Lapanjang, I. (2015). Perkecambahan dan pertumbuhan benih pala (*Myristica fragrans* Houtt) akibat lama perendaman pada atonik dan komposisi media tanam. *Mitra Sains,* 3(2):96-108.

Vaidehi, G., Subramanian, S., and Vinila, J.A. (2017). Influence of fertilizer levels on growth, yield and economics of nutmeg (*Myristica fragrans* Houtt). *Plant Archives,* Vol. 17 No. 1. 201-206.

Wattimena, A.Y. (2018). Pengaruh pemberian Pupuk NPK terhadap pertumbuhan bibit tanaman pala (*Myristica fragran* Houtt). *Jurnal Agriment*, 3(1):42-46.

Wong, W.S., Tan, S.N., Ge, L., Chen, X., and Yong, J.W.H. (2015). The importance of phytohormones and microbes in biofertilizers. *Bacterial metabolites in sustainable agroecosystem*, 105-158.

Yahaya, S.M., Mahmud, A.A., Abdullahi, M., and Haruna, A. (2023). Recent advances in the chemistry of nitrogen, phosphorus and potassium as fertilizers in soil: a review. *Pedosphere*, 33(3):385-406.