Agrotechnology Research Journal
Volume 8, No. 1, June 2024, pp. 30–36

ISSN 2655-7924 (Print)
ISSN 2614-7416 (Online)
https://jurnal.uns.ac.id/arj
doi:10.20961/agrotechresj.v8i1.83639

Role of Growth Regulators and Plant Media on Growth and Yields of Mint

Sulandjari Sulandjari*, Bambang Pujiasmanto, Supriyono Supriyono, Puji Harsono, Nurin Adyanisa Fajrin

Department of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, 57126 Central Java, Indonesia

Received **January 20, 2024;** Accepted **February 28, 2024**

ABSTRACT

There is a significant industrial demand for products produced by the mint plant (*Mentha piperita* L.), yet Indonesia cannot meet all of that need. One of the efforts to increase mint plant production is using manure and atonic growth regulators in the right concentration. The method used was a Factorial Randomized Complete Block Design (RCBD) with two factors. The first factor was the composition of the planting media (soil: husk charcoal, soil: husk charcoal; cow manure, soil: husk charcoal: goat manure, soil: husk charcoal: chicken manure, with a ratio of 1: each: 1:1). The second factor was the atonic concentration (0, 1, 2, and 3 $mL.L^{-1}$). The results showed that using chicken manure gave the best results for growth and yield. Atonic administration with a concentration of 2.05 $mL.L^{-1}$ gave optimum results on the fresh weight of roots, and a concentration of 2,06 $mL.L^{-1}$ gave optimum results on the dry weight of roots. The combination of the two treatments did not significantly affect the observed variables.

Keywords: Compost manure; Charcoal husk: Goat manure; Cow manure; *Mentha piperita*

***Cite this as (CSE Style)*:** Sulandjari S, Pujiasmanto B, Supriyono S, Harsono P, Fajrin NA. 2024. Role of growth regulators and plant media on growth and yields of mint. Agrotechnology Res J. 8(1):30–36. https://dx.doi.org/10.20961/agrotechresj.v8i1.83639.

INTRODUCTION

Mint (*Mentha piperita* L.; family Labiatae) is an important flavoring ingredient commonly used worldwide. Indonesians widely use mint because it contains menthol, which can be mixed into products. Fresh or dried leaves of Mentha species are used as spices, and these plants' essential oils (EO) are used as food and beverage flavorings, fragrances, and fungicides or insecticides in many pharmaceutical and industrial products (Ram and Kumar 1998). Mentha piperita is rich in menthol, I-menthone, pulegone, piperitone, menthol acetate, piperitenone menthone, carvone, menthofuran, isomentone, methyl acetate, and isopulegol so it can be used as an antioxidant. Menthol, a crystalline compound obtained from peppermint oil, has a pleasant taste and aroma as well as a cooling anesthetic effect and is used in confectionery, pharmaceutical, oral health care, cosmetics, tea, and tobacco products (Rachitha et al. 2017).

The industrial need for products produced by mint plants is huge, but Indonesia still needs to meet this need. Data from the Ministry of Industry shows that peppermint oil imports continue to increase yearly, even reaching US$ 529.5. Most of the essential ingredients for products are ultimately obtained through imports. Based on this, efforts need to be made to increase mint production. One effort to increase production is to improve the planting media.

Planting media provides mechanical support for plants and provides nutrients and water for plant growth. It must have suitable porosity and structure and sufficient water and nutrient retention. The composition of planting media, such as soil and rice husks, can provide good aeration and drainage because the characteristics of the planting media are porous and charcoal husks are lighter. When watered with water, the composition of the planting media, soil, and rice husks will retain moisture but will not be saturated with water. Tedjasarwana et al. (2009) stated that rice husks are a suitable medium for binding nutrient solutions because they have good drainage characteristics, high permeability, and good porosity in plant roots. The research results of Puspitasari et al. (2021) also showed that the combination of rice husk treatment with nutrients gave good results on the growth of pakcoy plants.

Organic fertilizer is a carbon-based compound that increases productivity and improves plant quality. This fertilizer has various advantages over chemical fertilizers. Organic fertilizer is a cheap and environmentally friendly raw material with extraordinary prospects in providing nutrients to reduce excessive dependence on chemical fertilizers (Bajeli et al. 2016). Organic fertilizers, including cow manure, chicken manure, and sheep manure, can be used for crop production as a substitute for synthetic fertilizers (Øvsthus et al. 2015). Organic fertilizer increases soil fertility without leaving residual effects in the soil and is cheaper than synthetic fertilizer. Manure is suitable as a

**Corresponding Author*:
E-Mail: sulandjari@staff.uns.ac.id

source of N, P, and K; it also contains amino acids, which are needed for photosynthetic activity and accumulation of dry matter and continue to increase crop yields (Chang et al. 2007).

Plant growth regulators are organic substances other than nutrients, which are synthesized in plants, causing changes in the metabolism of their cells. The synthesis of several plant hormones is negatively influenced by environmental factors, which cause inhibition of plant physiological processes and ultimately limit their growth potential (Çopur et al. 2010). This plant hormone is involved in various processes, including plant growth and development, cell division, cell elongation, differentiation, and apical dominance. Root development and absorption and transport of nutrients by roots are directly related to endogenous hormone levels (Wang and Lin 2002). Application of these hormones in low concentrations regulates growth, differentiation, and development through promotion or inhibition (Naeem et al. 2004), and allows physiological processes to occur at a standard rate (Gulluoglu 2004). Auxins are a class of phytohormones that control various plant growth and development processes. Auxin is known primarily for its ability to induce cell elongation and stimulate cell division and root initiation, among other things (Zhao 2010).

MATERIALS AND METHODS

Time and location

The research was carried out at the Studio Tani screenhouse located at Tlogo Village, Ngargoyoso District, Karanganyar Regency at coordinates 7º South Latitude and 111º East Latitude with an altitude of 900 meters above sea level. The research was carried out for 10 weeks from November 2022 to January 2023. The materials used in this research were planting materials in the form of mint stem cuttings, soil, manure, auxin, and distilled water. Prepare polybags measuring 25 cm x 25 cm and planting media based on each treatment. The planting media used for research were soil and husk charcoal with a mixture of different types of fertilizer according to the treatment.

Materials and methods

Atonik (Auxin) is given by soaking the mint stem cuttings for 180 minutes in a container with a concentration according to the treatment. The Atonik that will be used is first diluted using distilled water according to each treatment. Dilution was carried out by dissolving the atonic according to the treatment with 1 L of distilled water. The research was carried out using a factorial Complete Randomized Block Design (RCBD) with two factors. The first factor is the composition of the planting medium, namely: M0, Soil + charcoal husk; M1, Soil + husk charcoal + cow manure; M2, Soil + husk charcoal + goat manure; and M3, Soil husk charcoal + chicken manure, with each ratio 1:1:1. The second factor is soaking auxin with different concentrations, namely: A0, Water; A1, 1 mL.L^{-1}; A2, 2 mL.L^{-1}; and A3, 3 mL.L^{-1}. Each treatment combination was repeated 3 times, so there were 48 experimental units.

The research stages consist of preparing planting media, planting, maintaining, and harvesting. Media preparation is carried out by mixing soil, husk charcoal, and manure according to the treatment in a ratio of 1:1:1. Maintenance includes watering, weed management, and pest control. Watering is done every 2 days. Harvesting is done when the plant has many leaves, is dark green, and emits a fragrant aroma. Harvesting is done when the plants are 10 weeks after planting, and the mint plant looks like it has lots of leaves, is green in color, and emits a fragrant aroma. The fresh weight of the shoots and roots was observed by separating them and then weighing them. The way to harvest mint is to separate all parts of the plant using the planting medium to observe the plant's fresh and dry weight. The dry weight of the shoots and roots was observed by roasting the shoots and roots and weighing them.

Data analysis

Data were analyzed using analysis of variance (ANOVA) at 5% level, then continued with the Duncan's Multiple Range Test (DMRT) 5% and regression tests, as well as correlation tests to determine the relationship between variable observations.

RESULTS AND DISCUSSION

The soil media in this research used Andosol-type soil. Preliminary soil analysis was carried out in the soil physics and chemistry laboratory UNS (2023) with appreciation to medium fertility and high cation exchange coefficient. The composition of the planting medium is essential in plant cultivation. The addition of fertilizer as a planting medium needs to be done with the right composition so that plants get the nutrients they need. Analysis of cow, goat, and chicken manure in this study is presented in Table 1.

Table 1. Chemical analysis of organic manure

Content	Unit	Value			Quality
		Cow	Goat	Chicken	
N-total	%	1.58	1.09	1.09	>2%
P_2O_5	%	1.48	1.30	1.30	>2%
K_2O	%	1.33	2.16	2.16	>2%
pH	-	7.12	7.08	7.08	4.00-9.00
C-organic	%	22.43	20.90	20.90	>15%
C/N ratio	-	14.20	19.17	19.17	≤25

Table 1 shows that the three manures do not meet the quality standards as an organic fertilizer according to the Indonesian Ministry of Agriculture, however with various doses and media compositions it is possible to increase the growth and yield of peppermint. Cow manure is one of the fertilizers that is widely used in plant cultivation. Hafizah and Mukarramah (2017), stated that cow dung has high levels of fiber such as cellulose, and also contains quite high levels of essential macro and micronutrients. The research results of Gerami et al. (2016) stated that the use of cow manure in oregano plantations with different compositions had a significant effect on leaf area, fresh and dry plant weight, and plant stem diameter.

Rizal (2017), stated that the element N can help plants convert carbohydrates produced in the photosynthesis process into protein, thereby increasing the width, length, and number of leaves. The results of the chemical analysis of cow manure showed relatively low C/N levels. The C/N ratio influences the availability of nutrients in the fertilizer. A low C/N ratio means that the nutrients available to plants are high and plants can meet their daily needs. Suryani et al. (2022) stated that organic fertilizer that has a low C/N ratio means the organic fertilizer will be absorbed more quickly by plants, because of the low C/N, the N mineralization process is more dominant than N immobilization so that the organic material can be a source of N for the plant. The pH of the cow manure used is moderate and good for plants.

Another fertilizer used in this research was goat manure. Sadsoeitoeboen et al. (2022) stated that goat manure is widely used because it is widely available and environmentally friendly. Goat manure has a lower water content than cow and chicken manure. This fertilizer has a hard texture so it takes a long time to decompose so that the nutrients in the fertilizer can last longer in the soil.

Based on the results of the chemical analysis of goat manure, it was found that the C/N ratio was 19.17. Wijaksono et al. (2016) stated that the higher the C/N ratio, the fewer nutrients available. The soil C/N ratio is 10-20, so fertilizer with a C/N close to the soil C/N can be used directly. The K percentage of goat manure is 2.16. This percentage is higher than the percentage of N and P. Walangitan et al. (2021) stated that goat manure generally has higher K nutrient levels than N and P. Xu et al. (2020) stated that potassium plays an important role in plant physiology as an enzyme activator in metabolism. The pH of goat manure is classified as neutral, namely 7.08.

Chicken manure is a fertilizer that has the highest NPK content compared to cow and goat manure. Muharam et al. (2022) stated that chicken manure can improve the physical, chemical, and biological properties of soil. This fertilizer also has higher N, P, and K contents compared to cow and goat manure. Asri et al. (2019) stated that high levels of nutrients in chicken manure occur because the liquid part or urine is mixed with the solid part.

Analysis of variance (Table 2) on growth parameters shows that media composition significantly affects all variables except root fresh weight. The auxin concentration treatment only had a significant impact on rooting variables. There is no interaction between the two treatment factors for all variables. The composition of the planting media of soil and rice husks can improve aeration and good drainage because of the porous and light nature of the media. The composition will retain moisture but not be saturated with water (Koesriharti and Istiqomah 2019).

Table 3 shows that manure has a better effect on plant vegetative growth because it encourages leaf development and accelerates plant maturity with a higher rate of cell multiplication and differentiation, resulting in better vegetative growth. Manure with high nitrogen elements can increase plant height. Rahman et al. (2017) stated that the nitrogen element in manure can influence the growth of the apical meristem for plant growth.

The results of the analysis of variance in (Table 2) show that the single factor of planting media composition has a real influence on plant height. Atonic concentration does not influence plant height. There is no interaction between planting medium composition and atonic, which affects plant height. Each planting media composition treatment with the addition of manure significantly affected the planting media composition treatment without the addition of manure. Alfiah and Gunawan (2017), stated that the application of manure significantly affected the length of watermelon stems.

Based on the results of the influence of planting media composition on the growth and yield of mint plants in (Table 3), the highest average plant height, namely for plants with planting media mixed with chicken manure, is 81.07 cm. These results align with the research results of Putra et al. (2020), which state that chicken manure provides the highest plant height results compared to cow manure and goat manure treatments. The nutrient content in the soil determines plant height growth. Sufficient nutrient content in the soil will increase plant growth. Alfiah and Gunawan (2017) stated that manure contains nutrients and microorganisms that will help improve soil structure. A good soil structure will increase aeration and moisture, so the development of beneficial microorganisms for growth will also be good. Based on the chemical analysis of chicken manure in (Table 1), the N, P, and K content in chicken manure is higher than the other two fertilizers.

Table 2. Anova significance of various planting media compositions and Auxin concentrations on the growth and yield of mint

Variable	Media Compositions (M)	Concentration Auxin (A)	Interaction (MxA)
Plant height	0.00*	0.34 ns	0.37 ns
Number of leaf	0.00*	0.33 ns	0.60 ns
Leaf area (cm2)	0.00*	0.07 ns	0.51 ns
Weight of fresh shoot (g)	0.00*	0.24 ns	0.38 ns
Weight of dry shoot (g)	0.00*	0.14 ns	0.16 ns
Weight of fresh root (g)	0.01*	0.01*	0.23 ns
Dry weight of root (g)	0.66 ns	0.00*	0.16 ns

Remark: ns = no significant effect at the 5% level * = significant effect at the 5% level%

Table 3. Effect of planting media composition on plant height, number of leaves, and number of shoots at the 10th week

Planting Media	Plant height (cm)	Number of leaves	Leaf area (cm^2)
Soil:husk charcoal	43.42±14.54b	137.50±16.61c	435.81±105.54c
Soil:charcoal husk:cow manure	79.31±16.80a	730.75±128.34ab	5409.94±2515.82ab
Soil:charcoal husk:goat manure	69.45±23.89a	644.00±206.82b	3938.05±2679.22b
Soil:charcoal husk:chicken manure	81.07±22.34a	774.67±175.58a	5643.80±2424.36a

Remark: Numbers followed by the same letter in the same column indicate no significant difference at the DMRT level of 5%

The nitrogen content in chicken manure in this study was relatively high. The nitrogen content in chicken manure will help plant vegetative growth. This nitrogen functions as a form of assimilation, which will later influence the cell division process. There is increasing growth and development of the vegetative phase due to the ability of chicken manure to provide amino acids necessary to increase photosynthesis and dry matter accumulation (Jigme et al. 2015). Exogenous auxin given to plants can increase plant height. Auxin functions for root elongation (de Jong et al. 2009). The media composition treatment with chicken manure showed that its effect on leaf area was significantly more significant than the control and other treatments.

This increase in the number of leaves can occur due to the plant's nutrient needs being met. One of the nutrients that influences the increase in the number of leaves is nitrogen, which plays a role in photosynthesis. Edi (2014) stated that manure contains nitrogen elements, which can increase the number of leaves. The increasing number of leaves will increase photosynthesis, which will later play a role in plant growth. Sumerta et al. (2017) stated that increasing the amount of manure will significantly increase the number of leaves.

The availability of balanced nutrients is essential for plants to produce optimal growth. Naturally, mature manure as an organic material is used to improve the soil's physical, chemical, and biological properties, also causing the formation of humus, which will increase the strength of the roots in absorbing nutrients for plant growth and development. Fresh root weight is an essential parameter in plant observation. Table 4 shows that cow manure and chicken manure could increase root fresh weight higher than goat manure and control. Fresh weight and shoot dry weight increased higher than the control. Roots are the part of the plant whose function is to transport nutrients and water from the planting medium to be translocated to the leaves for photosynthesis (Baldi and Toselli 2013). The composition of the planting media that provides the highest fresh shoot weight is M3, a mixture of soil, husk charcoal, and chicken manure with an average weight of 62.76 g (Table 4).

The number of leaves and plant height can influence plant fresh weight. Maryam et al. (2015) stated that the canopy weight per plant can increase due to plant height, length, and number of leaves. The large size of the plant canopy is also evidence that the plant prioritizes food reserves resulting from photosynthesis stored in the plant canopy. The high nutrient content in chicken manure also affects the fresh weight of plant shoots. The high nitrogen content in chicken manure helps the photosynthesis process, affecting mint plants' growth. Marlina (2018) stated that nitrogen has a role as part of protoplasm, especially as part of proteins and chlorophyll components. Garrido et al. (2023) noted that well-formed plant chlorophyll would run the photosynthesis process well, producing good photosynthesis. This good photosynthesis will trigger plant growth and development, especially in the fresh weight of the crown.

The results of the analysis of variance in (Table 2) show that the phytohormone Atonik has a real influence on root fresh weight. The atonic growth regulator is auxin, which increases cell growth and plant elongation. This hormone will help plant cells elongate and increase the roots' fresh weight (Djanaguiraman et al. 2005). It is argued that auxin is a hormone involved in cell division, cell differentiation, and cell enlargement, which can influence plant growth and development.

Majda and Robert (2018) stated that auxin in plants functions to soften cell walls so that the ability of cell walls can increase along with the ability of roots to take up water due to pressure differences. Sitinjak (2015) stated that the hormone auxin works by elongating cells and stimulating specific proteins in the plasma membrane to pump hydrogen ions into the cell wall. This ion will activate certain enzymes that can break down the cellulose that makes up cell walls so that plant cells will elongate due to the influx of water by osmosis. The water absorption level in the roots will also affect the fresh weight of the roots. Suminar et al. (2017) stated that fresh root weight indicates the level of water and nutrient absorption by the plant.

The results of the orthogonal polynomial test in (Figure 1.) show that the application of atonic with a specific concentration significantly affects the fresh weight of the roots and forms a cubic graph with a correlation coefficient of (r = 0.58). This value shows a moderate relationship between giving atonic concentration and fresh root weight.

Table 4. Effect of planting media composition on shoot and root

Planting Media	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of roots (g)
Soil:husk charcoal	5.51±02.22b	0.93±0.47b	4.03±1.07b
Soil:charcoal husk:cow manure	54.97±34.20a	6.31±3.77a	7.19±3.07a
Soil:charcoal husk:goat manure	49.74±28.09a	5.73±2.52a	6.15±4.46ab
Soil:charcoal husk:chicken manure	62.76±37.08a	6.95±3.89a	7.85±4.18a

Remark: Numbers followed by the same letter in the same column indicate no significant difference at the DMRT level of 5%.

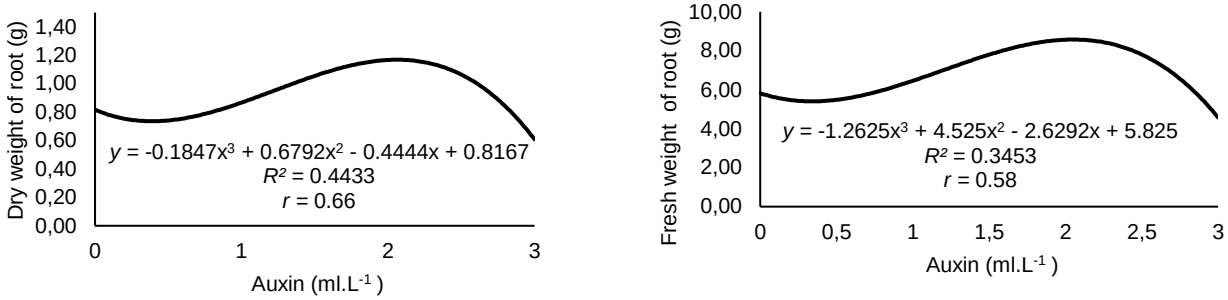

Figure 1. Fresh and dry weight of mint roots treated by auxin

The optimum atonic concentration of 2.05 mL.L^{-1} gave the highest fresh root weight, 8.57 g. Supriyono et al. (2022) stated that plants can readily absorb atonic but will inhibit growth if used at high concentrations. Habeahan et al. (2021) noted that the administration of growth regulators will only be effective at specific concentrations. Providing a concentration that is too low will be ineffective for growth, while a high concentration will inhibit plant growth.

CONCLUSIONS AND SUGGESTIONS

Limited to this research, the results showed that the use of chicken manure gave the best results for plant height, number of leaves, number of shoots, leaf area, fresh weight, and dry weight of shoots, as well as fresh weight roots. Atonic administration with a concentration of 2,05 mL.L^{-1} gave optimum results on the fresh weight of roots, and a concentration of 2,06 mL.L^{-1} gave optimum results on the dry weight of roots. The combination of the two treatments did not have a significant effect on the observed variables.

DAFTAR PUSTAKA

Alfiah NL, Gunawan I. 2017. Pertumbuhan semangka (*Citrulus vulgaris* Schard) dengan menggunakan beberapa jenis pupuk organik. J Sungkai. 5(1):22–31.

Asri B, Arma R, Riska R. 2019. Respon pertumbuhan dan produksi varietas bawang merah (*Allium cepa* L.) terhadap pemberian pupuk kandang. J Agrominansia. 4(2):167–175.

Bajeli J, Tripathi S, Kumar A, Tripathi A, Upadhyay RK. 2016. Organic manures are a convincing source for quality production of Japanese mint (*Mentha arvensis* L.). Ind Crops Prod. 83:603–606. https://doi.org/10.1016/j.indcrop.2015.12.064.

Baldi E, Toselli M. 2013. Root growth and survivorship in cow manure and compost amended soils. Plant, Soil Environ. 59(5):221–226. https://doi.org/10.17221/857/2012-PSE.

Chang E-H, Chung R-S, Tsai Y-H. 2007. Effect of different application rates of organic fertilizer on soil enzyme activity and microbial population. Soil Sci Plant Nutr. 53(2):132–140. https://doi.org/10.1111/j.1747-0765.2007.00122.x.

Çopur O, Demirel U, Karakuş M. 2010. Effects of several plant growth regulators on the yield and fiber quality of cotton (*Gossypium hirsutum* L.). Not Bot Horti Agrobot Cluj-Napoca. 38(3):104–110.

Djanaguiraman M, Sheeba JA, Devi DD, Bangarusamy U. 2005. Response of cotton to atonik and TIBA for growth, enzymes and yield. J Biol Sci. 5(2):158–162. https://doi.org/10.3923/jbs.2005.158.162.

Edi S. 2014. Pengaruh pemberian pupuk organic terhadap pertumbuhan dan hasil tanaman kangkong darat(*Ipomea reptanspoir*). J Agrik. 3(1):17–24.

Garrido A, Conde A, Serôdio J, De Vos RCH, Cunha A. 2023. Fruit photosynthesis: More to know about where, how and why. Plants. 12(13):2393. https://doi.org/10.3390/plants12132393.

Gerami F, Moghaddam PR, Ghorbani R, Hassani A. 2016. Effects of irrigation intervals and organic manure on morphological traits, essential oil content and yield of oregano (*Origanum vulgare* L.). An Acad Bras Cienc. 88(4):2375–2385. https://doi.org/10.1590/0001-3765201620160208.

Gulluoglu L. 2004. Determination of usage of plant growth regulators in soybean (*Glycine max* Merr) farming under Harran plain conditions. J Fac Agric. 8:17–23.

Habeahan KB, Cahyaningrum H, Aji HB. 2021. Pengaruh komposisi media tanam dan zpt atonik terhadap pertumbuhan bibit kakao (*Theobroma cacao* L.). J Ilmu-Ilmu Pertan Indones. 23(2):106–111. https://doi.org/10.31186/jipi.23.2.106-111.

Hafizah N, Mukarramah R. 2017. Aplikasi pupuk kandang kotoran sapi pada pertumbuhan dan hasil tanaman cabai rawit (*Capsicum frustescens* L.) di lahan rawa lebak. Ziraa'Ah. 42(1):1–7.

Jigme J, Jayamangkala N, Sutigoolabud P, Inthasan J, Sakhonwasee S. 2015. The effect of organic fertilizers on growth and yield of broccoli (*Brassica Oleracea* L. var. *italica* Plenck cv. Top Green). J Org Syst. 10(1):9–14.

de Jong M, Mariani C, Vriezen WH. 2009. The role of auxin and gibberellin in tomato fruit set. J Exp Bot. 60(5):1523–1532. https://doi.org/10.1093/jxb/erp094.

Koesriharti K, Istiqomah A. 2019. Effect of composition growing media and nutrient solution for growth and yield pakcoy (*Brassica rapa* L. chinensis) in hydroponic substrate. PLANTROPICA Journal of Agricultural Science. 2016. 1(1): 6-11.

Majda M, Robert S. 2018. The role of auxin in cell wall expansion. Int J Mol Sci. 19(4):951. https://doi.org/10.3390/ijms19040951.

Marlina G. 2018. Uji berbagai media tanam dan pemberian air kelapa muda terhadap pertumbuhan bibit kelapa sawit (*Elaeis quineensis*. Jacq) di main nursery. J Pertan UMSB. 2(1):10–18.

Maryam A, Susila AD, Kartika JG. 2015. Pengaruh jenis pupuk organik terhadap pertumbuhan dan hasil, panen tanaman sayuran di dalam Nethouse. Bul Agrohorti. 3(2):263–275. https://doi.org/10.29244/agrob.v3i2.15109.

Muharam RA, Mutakin J, Maesyaroh SS. 2022. Pengaruh berbagai konsentrasi zat pengatur tumbuh hydrasil dan dosis pupuk kandang ayam terhadap pertumbuhan dan hasil Tanaman pakchoy(*Brassica rapa* L.). JAGROS J Agroteknologi dan Sains (Journal Agrotechnology Sci. 6(1):44. https://doi.org/10.52434/jagros.v6i1.1618.

Naeem M, Bhatti I, Ahmad RH, Ashraf MY. 2004. Effect of some growth hormones (GA3, IAA and kinetin) on the morphology and early or delayed initiation of bud of lentil (*Lens culinaris* Medik). Pakistan J Bot. 36(4):801–809.

Øvsthus I, Breland TA, Hagen SF, Brandt K, Wold A-B, Bengtsson GB, Seljåsen R. 2015. Effects of organic and waste-derived fertilizers on yield, nitrogen and glucosinolate contents, and sensory quality of broccoli (*Brassica oleracea* L. var. *italica*). J Agric Food Chem. 63(50):10757–10767. https://doi.org/10.1021/acs.jafc.5b04631.

Puspitasari L, Mareta S, Thalib A. 2021. Karakterisasi senyawa kimia daun mint (*Mentha* sp.) dengan metode FTIR dan kemometrik. Sfj Sainstech Farma J Ilmu Kefarmasian. 14(1):5–11.

Putra SS, Putra ETS, Widada J. 2020. The effects of types of manure and mycorrhizal applications on sandy soils on the growth and yield of curly red chili (*Capsicum annum* L.). Caraka Tani J Sustain Agric. 35(2):258–267. https://doi.org/10.20961/carakatani.v35i2.34971.

Rachitha P, Krupashree K, Jayashree G, Gopalan N, Khanum F. 2017. Growth inhibition and morphological alteration of Fusarium sporotrichioides by Mentha piperita essential oil. Pharmacognosy Res. 9(1):74–79. https://doi.org/10.4103/0974-8490.199771.

Rahman AA, Barus A, Sipayung R. 2017. Respons pertumbuhan dan produksi tanaman kedelai terhadap pemberian pupuk organik cair dan mulsa. J Agroekoteknologi. 5(1):85–92.

Ram M, Kumar S. 1998. Yield and resource use optimization in late transplanted mint (*Mentha arvensis*) under subtropical conditions. J Agron Crop Sci. 180(2):109–112. https://doi.org/10.1111/j.1439-037X.1998.tb00378.x.

Rizal S. 2017. Pengaruh nutrisi terhadap perrumbuhan tanaman sawi pakcoy (*Brasicca rapa* L.) yang di tanam secara hidroponik. Sainmatika. 14(1):38–44.

Sadsoeitoeboen PD, Rahangmeta PA, Syaefullah BL, Sritiasni S. 2022. Pemanfaatan feses kambing sebagai pupuk padat terhadap pertumbuhan rumput odot (*Pennisetum purpureum* cv. Mott) di Kampung Desay, Distrik Prafi, Provinsi Papua Barat. J Livest Sci Prod. 6(2):444–449. https://doi.org/10.31002/jalspro.v6i2.6548.

Sitinjak RR. 2015. The growth response stem cuttings of roses (*Rosa* sp) to plant growth regulator Atonik and Rootone-F. J Chem Pharm Res. 7(9):557–562.

Sumerta IM, Ilahude Z, Pembengo W. 2017. Respon pertumbuhan dan hasil tanaman nilam (*Pogostemon cablin* Benth) terhadap pemberian pupuk kandang dan pupuk organik cair. Jatt. 6(3):284–291.

Suminar R, Suwarto S, Purnamawati H. 2017. Pertumbuhan dan hasil sorgum di tanah latosol dengan aplikasi dosis pupuk nitrogen dan fosfor yang berbeda. J Agron Indones. 45(3):271–277. https://doi.org/10.24831/jai.v45i3.14515.

Supriyono E, Lideman L, Hastuti YP, Arifka AR. 2022. Combination effect of atonic growth regulator with PES (Provasoli Enrich Seawater) on Seaweed (*Eucheuma Cottonnii*) growth. IOP Conf Ser Earth Environ Sci. 1033(1):012019. https://doi.org/10.1088/1755-1315/1033/1/012019.

Suryani R, Masulili A, Sutikarini S, Tamtomo F. 2022. Utilization of liquid organic fertilizer of pineapple waste to improving growth of sweet corn plant in red yellow podsolic soil. Int J Multi Discip Sci. 5(1):30–36. https://doi.org/10.26737/ij-mds.v5i1.3160.

Tedjasarwana R, Nugroho EDS, Herlinaa D, Darliah D. 2009. Tanggap pertumbuhan mawar mini dan produksi bunga pada berbagai daya hantar listrik dan komposisi media tanam. J Hortik. 19(4):396–406.

Walangitan FSBR, Supit JM, Kawulus RI. 2021. Pengaruh pemberian pupuk kandang kambing terhadap pertumbuhan tanaman kangkung darat (*Ipomoea reptans*) pada tanah marginal. Cocos. 13(2):1–12.

Wang SY, Lin S-S. 2002. Composts as soil supplement enhanced plant growth and fruit quality of strawberry. J Plant Nutr. 25(10):2243–2259. https://doi.org/10.1081/PLN-120014073.

Wijaksono RA, Subiantoro R, Utoyo B. 2016. Pengaruh lama fermentasi pada kualitas pupuk kandang kambing. J Agro Ind Perkeb J AIP. 4(2):88–96.

Xu X, Du X, Wang F, Sha J, Chen Q, Tian G, Zhu Z, Ge S, Jiang Y. 2020. Effects of potassium levels on plant growth, accumulation and distributi on of carbon, and nitrate metabolism in apple dwarf rootstock seedlings. Front Plant Sci. 11(June2020):00904. https://doi.org/10.3389/fpls.2020.00904.

Zhao Y. 2010. Auxin biosynthesis and its role in plant development. Ann Rev Plant Biol. 61(1):49–64. https://doi.org/10.1146/annurev-arplant-042809-112308.