CELL BIOLOGY & DEVELOPMENT
Volume 6, Number 1, June 2022 E-ISSN: 2580-4499
Pages: 32-40 DOI: 10.13057/cellbioldev/v060105

Effect of the media type and auxin concentration on the growth of cuttings seedlings of pepper (*Piper nigrum*)

SITI AMANAH, M.T.H. SRI BUDIASTUTI♥, ATO SULISTYO
Program of Agronomy, Faculty of Agriculture, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57126, Central Java, Indonesia.
Tel.: +62-271-637457, ♥email: budiastutiw@gmail.com

Manuscript received: 4 March 2022. Revision accepted: 30 May 2022.

Abstract. *Amanah S, Budiastuti MTHS, Sulistyo A. 2022. Effect of the media type and auxin concentration on the growth of cuttings seedlings of pepper (*Piper nigrum*). Cell Biol Dev 6: 32-40.* Pepper (*Piper nigrum* L.) is an export commodity and has become one of the Indonesian sources of income. It is necessary to develop the best cultivation for increasing pepper production. Vegetative propagation has been chosen in this research, using manure as part of the media and auxin as a growth hormone. The research aims to find the best media and auxin concentration for the ideal growth of pepper grafting. The research conducted in Manyaran Wonogiri, Indonesia, with RCB design consists of two factors arranged in the factorial method. The first factor is the kind of media (soil, soil + manure, soil + manure + husk), and the second is auxin's concentration (0 g/L, 12.5 g/L, 25 g/L, 37.5 g/L; 50 g/L). Observation variables are bud growth time, number of buds, length of bud, number of leaves, leaf width, number of roots, length of root, and life percentage of cuttings. Data were analyzed by F test at 1% and 5% and continued with DMRT at 5% if the treatment had a significant effect. It is also continued with regression if there was an interaction between treatments. The longest bud was found on soil + manure + husk (12.28 cm) and followed by soil + manure (10.57 cm) and soil (6.15 cm) in the low level, respectively. The study revealed that the bud length and the number of roots were influenced by auxin concentration. The longest bud was found using 12.5 g/L of auxin (15.14 cm), followed by 50 g/L, 25 g/L, 0 g/L, and 37.5 g/L in the low level, respectively (12.05 cm, 7.72 cm, 7.67 cm, 5.75 cm). The highest number of roots was found on 0 g/L and 12.5 g/L of auxin (7.78), followed by 50 g/L, 25 g/L, and 37.5 g/L in the low level, respectively (4, 3.43, 2.33). The number of roots and percentage of life cuttings showed an interaction between the two factors. The number of roots on the soil shows a parabolic response with auxin. In the beginning, the number of roots decreased and then increased with increasing auxin concentration. The number of roots on soil + manure and soil + manure + husk showed the same pattern with auxin concentration. Almost 100% of life cuttings have been found on all media and auxin concentrations. Soil + manure with 25 g/L auxins and soil + manure + husk with 50 g/L auxins caused 33.33% and 66.67% life cuttings, respectively.

Keywords: Auxin, growth, media type, pepper, *Piper nigrum*

INTRODUCTION

Pepper (*Piper nigrum* L.) is an important crop in Indonesia because the yield of this commodity (pepper drupes) is a source of foreign exchange (Sopialena et al. 2018). Pepper is an export commodity that in 2000 had reached 68,727 tons and was valued at 221 million US$. Pepper exports rank sixth after rubber, oil palm, coffee, cocoa, and coconut. However, pepper productivity in Indonesia is still low compared to India and Malaysia (Azahari et al. 2021).

Given the very good prospects for this plant, pepper production needs to be developed with good cultivation efforts. It allows pepper farmers to increase their income and ultimately support the country's foreign exchange earnings. However, the reality is that farmers cultivate pepper plants very simply, as was done by pepper farmers in Manyaran Wonogiri. Pepper farmers in Manyaran only use soil media without adding manure (if manure is used, the dosage is not clear) or use PGR (growth regulators) in the nursery process, which results in poor plant growth because even though there are enough leaves, the roots have not grown perfectly (weak roots), so that when planted in the field, the opportunity to grow is very low.

Nurseries are indispensable as a way to provide planting material in large quantities. It is known that pepper plants can be planted directly vegetatively with the planting material in the form of stems with 7-9 segments. It is an obstacle to increasing crop production because planting material is limited, which is different if pepper plants are propagated vegetatively by seedlings in the form of stems with only 2-3 segments. Therefore, it becomes an opportunity for the availability of planting material quickly to support increased production.

The availability of healthy seedlings in large quantities is the key to the success of pepper production. Therefore, it is necessary to make nursery efforts that support the formation of healthy roots. The trick is to use a good planting medium for roots, which can provide nutrients and support root development (porous soil structure). Planting media with such conditions can be made by adding organic fertilizer (cow manure, husk) and a concrete step to utilize the available organic waste. Using mixed media of manure and husk can increase plant growth and yield (Zulia and Batubara 2020) because manure can provide organic matter and nutrients, improve soil's physical properties, and prevent water loss in the soil (Adugna 2016). In addition, husk plays a role in improving soil structure (better

drainage system), binding water, not easy to rot, K source, and not easy to compact.

In addition, the provision of auxin as a growth regulator (PGR), which can stimulate root growth, also could be applied. There is a lot of evidence that auxins affect stem growth and root formation. People know PGR (auxin) by Biooton and Rootone F (Artanti 2007). Jayusman's research (2005) showed that the concentration of Rootone F 1.5 g/40 mL gave the best results on the experimental parameters, namely the percentage of cuttings, the number of leaves, and the robustness of the seedlings. This study was used at 0 g/40 mL; 0.5 g/40 mL; 1 g/40 mL; 1.5 g/40 mL; and 2 g/40 mL concentrations.

The objectives of this study were: (i) to find a good planting medium for the growth of pepper cuttings seedlings, (ii) to obtain the administration of auxin that affected the growth of pepper cuttings, (iii) to reveal the relationship between planting media and auxin administration on the growth of pepper cuttings seedlings.

MATERIALS AND METHODS

Research place

This research was conducted in Demangan Village, Manyaran Sub-district, Wonogiri District, Central Java, Indonesia, at an altitude of 310 m above sea level.

Research design

This research was carried out in a factorial manner using a completely randomized design, with 2 treatment factors as follows:

Planting media consists of 3 kinds, namely:

M0: soil (control)

M1 : soil + manure (1:1)

M2 : soil + manure + husk (1:1:1)

Auxin concentration consists of 4 levels, namely: R0: control; R1 : 12.5 g/L; R2: 25 g/L; R3: 37.5 g/L; R4 : 50 g/L.

Thus, there are 15 treatment combinations. Each treatment was repeated 3 times so that there would be 45 treatment combinations.

Research procedure

Media and venue preparation

(i) Install paranet before starting the nursery to reduce sunlight, accelerating evaporation. (ii) Prepare and mix the media according to the treatment, then put it in a polybag measuring 14 x 20 cm. (iii) Prepare plastic and dry coconut leaves to cover the nursery.

Picking up the cutting material

(i) The cutting material was taken from the pepper plant in the Manyaran Wonogiri area in the afternoon. (ii) A sharp cutter was used to cut the cutting material so as not to be damaged. (iv) The cuttings used are taken from healthy and growing plants but not in flowering or fruiting conditions. (v) Cutting samples are taken from primary or climbing stems (not fruit branches).

Preparation of auxin treatment

(i) Dissolving auxin in water according to treatment. (ii) Stir the mixture first before dipping the cuttings. (iii) Dipping the cutting samples into the auxin mixture for 2 minutes before planting.

Planting

After taking the cutting samples, planting was carried out at 05.00 pm by inserting the cuttings into the media that had been prepared according to the treatment. The planting method is as follows: (i) Some of the media in the polybag is taken to be used as a place to insert cuttings that have been treated with auxin. (ii) The media is returned to the polybag carefully so that the position of the cuttings is right in the middle. (iii) The cuttings in polybags are watered sufficiently so that the media is tighter. (iv) The cutting samples are immediately placed in a nursery (concrete pipe culvert) with an air humidity of 70% and a temperature of 31°C. (iv) The concrete pipe culvert is covered with plastic trimmed with rubber tires, then given with dry coconut leaves

Upkeep

The upkeep includes watering with watering intensity according to media conditions and removing weeds or others that interfere with the growth of these pepper cuttings.

Observation variable

Sprouting time

The sprouting period is calculated when new shoots grow dark red (purple-red), then the shoots were observed every 2 weeks, beginning from 2 Weeks After Planting (WAP) to 12 WAP.

Number of shoots

The number of shoots was observed every 2 weeks, and the number of new shoots was counted on-site.

Shoot length

Shoot length was measured every 2 weeks from the stem where the shoots grew to the tip of the highest shoot.

Number of leaves

The number of leaves was calculated every 2 weeks, namely the leaves that have opened completely.

Leaf width

Leaf width was measured at the end of the study using millimeter paper. The procedure is that the leaves are drawn on millimeter paper which can be done by placing the leaves on millimeter paper, and the leaf pattern is followed. Leaf width is estimated based on the number of squares contained in the leaf pattern with the formula:

$$LD = n \times Lk \quad (1)$$

Where: LD: leaf width, n: number of squares; Lk: box width (cm^2)

Moreover, boxes with a size greater than or equal to half the reference size (cm^2) are selected to be considered in the above formula (Sitompul and Guritno 1995).

Number of roots

The number of roots calculated at the end of the study was the total number of roots per plant. The calculated roots are roots that emerge from the root neck and have root fibers that absorb nutrients in the soil.

Root length

Root length was measured at the end of the study from the root neck to the longest root tip.

Percentage of live cuttings

The percentage of live cuttings was calculated at the end of the study with the formula:

$$PSH = \frac{X \times 100\%}{T}$$

Where: PSH: percentage of live cuttings (%), X: number of live cuttings per treatment, T: number of replications in treatment (3)

Data analysis

Data were analyzed by analysis of variance based on the F test of 5% and 1%. It was continued with the 5% DMRT test if it had a significant effect. In addition, a regression analysis was performed to determine if there was an interaction.

RESULTS AND DISCUSSION

Seedling is one of the important stages in pepper cultivation, although pepper plants can be planted directly without going through the nursery process. The rate of photosynthesis will increase as the plant ages. The results of photosynthesis (photosynthate) are used for plant growth processes. Although growth occurs due to cell division and elongation processes, these processes require large amounts of carbohydrates.

The results showed that the media type significantly affected shoot length, while auxin concentration significantly affected shoot length and root number. Furthermore, the number of roots, media type, and auxin concentration showed a very significant interaction, and the percentage of live cuttings had significant interaction, too.

In detail, the discussion of each observation variable is as follows:

Time of shoot growing

One of the reasons for using cuttings to propagate plants vegetatively is that the time required to grow is faster. When shoot growth is an indicator of plant growth, the faster the shoot grows, the faster the time is needed for the plant to grow and develop. Shoots are formed from meristem cells that divide and form a bump/swelling at the end of the stem. The bump/swelling extends and encircles the tip (Gardner et al. 2017).

The type of media, the concentration of auxin, and their combination had no significant effect on shoot growth, which is one form of plant growth. Salisbury and Ross (2006) stated that growth in plants is limited to certain parts, which consist of several cells that have just been produced through the process of meristem cell division. It is the product of cell division that grows and causes growth. For example, the tip of the canopy has meristems that could form shoots. So when growing, shoots are more influenced by meristems.

The fastest shoot growth was in soil media with an auxin concentration of 50 g/L, and the longest shoot growth was in soil media with 12.5 g/L (Figure 1). Different types of growing media with different auxin concentrations did not significantly affect shoot growth, except for a slightly prominent auxin concentration of 12.5 g/L. Maybe auxin is a growth hormone inseparable from plant growth and development, and one of the roles of auxin is stimulating cell elongation in shoots (Artanti 2007). Gardner et al. (2017) also stated that added auxin could significantly affect shoot growth.

Number of shoots

Pepper plants have nodes as a place for roots or shoots to come out and internodes that separate one node from another. The type of media, the concentration of auxin, and the combination of the two had no significant effect on the number of shoots. It is because the number of shoots that are part of plant growth is more influenced by the meristems present in the cutting material used. Plant development could be explained in that the meristem cells will divide to produce new cells, and then new cells will grow and develop, which causes growth (Salisbury and Ross 2006).

The highest number of shoots was in the treatment of media of soil + manure + husk with an auxin concentration of 25 g/L (Figure 2). The combination of soil media gave the highest number of shoots at an auxin concentration of 37.5 g/L, while the combination of soil + manure media gave the highest number of shoots in the treatment without auxin.

The number of shoots in soil + manure + husk was more than in other media. Moreover, media is also more profitable because it is lighter and is one way of utilizing agricultural waste. Soil + manure + husk was the best-growing medium for the number of shoots because the growing media composition was complete by adding manure and husks. In addition, manures can provide additional organic matter in the growing media. Meanwhile, besides being an organic material, the husk can also improve the drainage of the growing media.

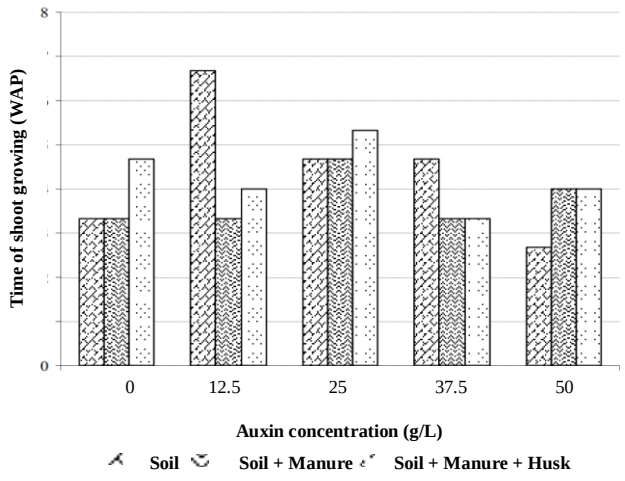

Figure 1. Average growth of pepper shoots on various media and auxin concentrations

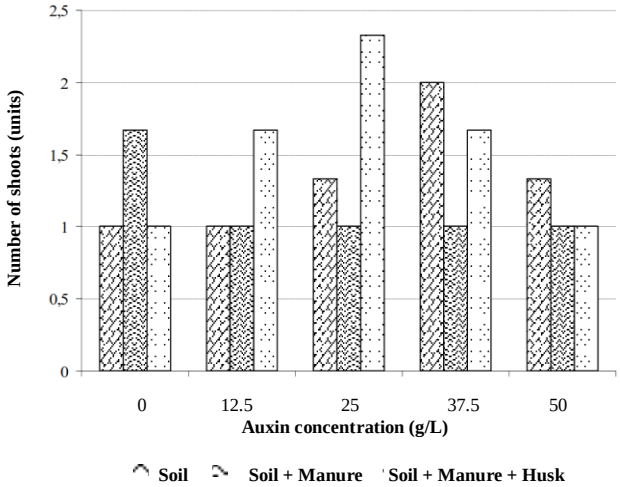

Figure 2. The average number of pepper shoots on various media and auxin concentration

According to Adnan et al. (2021), providing organic matter increases soil humus, reduces environmental pollution, and reduces nutrient depletion. Thus, applying organic matter can improve the physical properties and health of the soil. Meanwhile, husks play a very important role in improving soil structure so that the drainage system for planting media becomes better. Therefore, using mixed media of manure and husk can increase plant growth and yield (Zulia and Batubara 2020).

Shoots will grow if the concentration of cytokinin hormones is higher than auxin (Rineksane 2005). Auxin concentrations in plants can be high due to the accumulation of endogenous and exogenous auxins (Sairanen et al. 2012; Tian et al. 2013; Olatunji et al. 2017). It is suspected to be the cause of the best concentration of auxin in the number of shoots with soil + manure + husk media was 25 g/L. The administration of auxin at more than 25 g/L caused the accumulation of endogenous and exogenous auxin to be higher than the concentration of cytokinins, which could inhibit the shoot growth.

Shoot length

Planting media is a place to live for seedlings and find food that a suitable planting medium will improve plant growth and development. The growth that can be seen directly from the plant is the growth of shoot length.

Growth in stem height occurs in the intercalary meristems of the internodes. The internodes lengthen due to the increase in the number of cells and mainly due to the expansion of the cells. Growth due to cell division occurs at the base of the internode (intercalary), not the tip meristem. The amount of hormone in the intercalary meristem is limited because it is not produced by itself as occurs in the tip meristem, so growth regulators must be supplied from outside (Gardner et al. 2017).

The results of the data analysis showed that the type of media treatment and auxin concentration significantly affected shoot length (Table 1). However, these two treatments did not show any interaction with shoot length.

The longest shoot length produced was from a combination of soil + manure + husk treatment with an auxin concentration of 50 g/L, which was 24 cm. Thus it can be said that the right medium has a good effect on administering auxin. That is because the media supports plant growth outside (environment), while auxin is a growth regulator from within. So if these treatments are combined, it will have a better effect on plant growth.

The best planting media to maximize shoot length are soil media + manure + husk, soil media + manure, and soil media. It is because the more diverse the composition of the media, the better the growth. Soil media is the primary medium and is a control treatment. However, adding manure can give better yields on shoot length because manure is very good for supplying nutrients and improving soil quality. Manure is an organic fertilizer that can provide organic matter and nutrients, improve soil physical properties and restore lost nutrients. In addition, it can prevent water loss in the soil and the rate of water infiltration into the soil (Adugna 2016).

Moreover, adding husks to the planting media can also give better results because the husks can improve the drainage system by being easy to bind water, not easy to rot, and not easy to compact. It follows Dewi et al. (2007), who state that pepper plants require soil conditions that have good aeration and drainage.

Table 1. Average shoot length of pepper (cm) on various media and concentration of auxin (12 WAP)

Media type	Auksin concentration (g/L)					
	0	**12.5**	**25**	**37.5**	**50**	**Average**
Soil	6.5	12.83	3	2.08	6.33	6.15a
Soil + manure	6.33	18.67	16	6	5.83	10.57ab
Soil + manure + husk	10.17	13.91	4.17	9.17	24	12.28b
Average	7.67a	15.14b	7.72a	5.75a	12.05ab	

Note: Numbers followed by the same letter in one row or column are not significantly different in the Duncan test at the 5% level

In soil media, the longest shoot was 12.83 cm. In soil + manure media was 18.67 cm, while in soil + manure + husk medium, it was 24 cm (Table 1). So it can be said that the media treatment affected shoot length (the treatment was better than the control). Therefore, per the results of the F test, the media had a significant effect on shoot length.

The best auxin concentration at shoot length was 12.5 g/L (15.14 cm), then 50 g/L (12.05 cm). It follows Gardner et al. (2017), who stated that stems respond to auxin concentrations in a fairly wide range. Meanwhile, the auxin concentration of 37.5 g/L caused the shoot length to be lower than the control. It indicates that the growth of pepper-cutting seedlings requires the right concentration of auxin. Improper concentration will not stimulate the growth of pepper cuttings seedlings but will inhibit their growth.

The appropriate concentration of auxin for pepper-cutting seedlings on shoot length is 12.5 g/L. It follows the research of Olatunji et al. (2017) that plants require an appropriate concentration of auxin for their growth. An inappropriate concentration will not promote growth; on the contrary, it can even inhibit it. Artanti (2007) also stated that auxin was very influential on stem growth, but Dewi and Sabhara (2022) stated that the proper use of PGR would positively affect growth.

Number of leaves

The function of the leaves is to produce photosynthate, which plants need as a source of energy in growth and development (Dewi and Sabhara, 2022). Therefore, the highest number of leaves produced indicates the plant is experiencing better growth and development.

The type of media, the concentration of auxin, and the combination of the two had no significant effect on the number of shoots. According to Gardner et al. (2017), the number of nodes and internodes is the same as the number of leaves. All three have the same origin in the phytomer. The cutting material used in this study had the same nodes and internodes.

However, there were differences in the effect of the media type and auxin concentration on the number of leaves (Figure 3) because, according to Gardner et al. (2017), the number of leaves is also influenced by genetic and environmental factors. For example, leaf growth will be encouraged if sufficient water is available in the growing media.

The highest number of leaves produced was on soil + manure + husk with an auxin concentration of 50 g/L, while the second-highest number of leaves was in the same medium with an auxin concentration of 12.5 g/L. Therefore, it shows that soil + manure + husk with auxin was the proper medium with the ability to give the highest number of leaves for pepper cuttings.

Soil analysis showed that the exchanged K content of the soil was 0.23%. According to Sutedjo (1990), a fairly high K (no need to fertilize) is 0.3%, so adding husks in this medium can meet the K needs because husks are a source of K needed by plants.

Especially on soil + manure + husk treatment, adding auxin has a good effect on the number of leaves. However, the auxin concentration must be appropriate to obtain the optimal number of leaves; in this study, the highest number of leaves on the planting medium of soil + manure + husk was with an auxin concentration of 50 g/L. In comparison, with auxin concentrations of 25 g/L and 37.5 g/L, the number of leaves was less than that of 12.5 g/L. It shows that the effect of auxin absorption is observed from the concentration of auxin and the sensitivity of the recipient tissue (plant protein) (Salisbury and Ross 2006).

Leaf width

Leaves are generally considered the main photosynthetic-producing organs, so leaf observations are necessary to explain the growth processes that occur in the formation of plants. In addition, observation of leaves can be based on their function as light receivers and photosynthetic tools (Ren et al. 2018). On this basis, leaf width is the preferred parameter because the rate of photosynthesis per unit plant, in most cases, is determined largely by leaf width (Sitompul and Guritno 1995).

Large leaf width affects the growth of other plant organs. Increased leaf width is a form of plant growth resulting from cell division and elongation activity influenced by the availability of nutrients. Nitrogen is a nutrient that strongly supports the vegetative growth of plants, especially leaves.

Leaves are vegetative organs. Therefore, the N content influences their growth in the media. Soil analysis showed that the soil contained N (0.21%), and the manure contained N (1.44%), so combining these two growing media could increase the N content in the growing media used; thus, leaf growth can be increased.

The media type, the auxin concentration, and the combination of the two had no significant effect on leaf width. Because the leaves are part of the plant whose growth structure is certain (it will be dead to some extent), therefore media type and the concentration of auxin have no significant effect on the growth of leaf width (Salisbury and Ross 2006).

The best-growing media for leaf width is soil + manure + husk (Figure 4) because the planting medium has a complete composition. Manure adds organic matter, which means adding nutrients (especially N). Meanwhile, the husk improves the condition of the growing media by providing more air and water space (aeration and drainage).

The soil + manure media gave a smaller leaf width than the soil media. It is due to the addition of manure; even though it increased the N content needed for leaf growth, manure made water absorption greater than the soil media, so the planting medium was too much watering. This planting medium is also not accompanied by adding air space, while pepper plants require good aeration and drainage conditions (Dewi et al. 2007).

Leaf width on pepper cuttings seedlings with auxin treatment gave better leaf width than pepper cuttings without auxin treatment (control) (Figure 5). It is not following Rineksane's (2005) research that auxin could not increase leaf width. According to Marlin (2005), plants' growth and development (morphogenesis) treated with PGR are controlled by the balance and interaction of endogenous and exogenous PGR. So giving PGR (auxin) can affect the growth of pepper cuttings seedlings, especially leaf width.

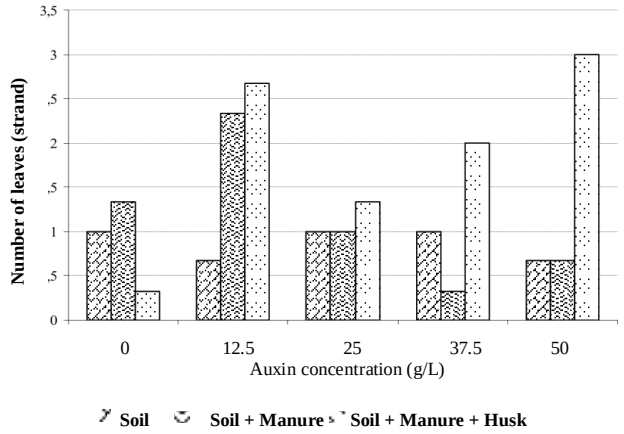

Figure 3. The average number of pepper leaves on various media and auxin concentrations

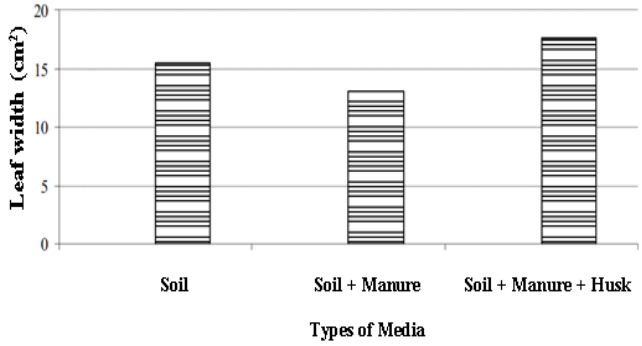

Figure 4. Average pepper leaf width on various media

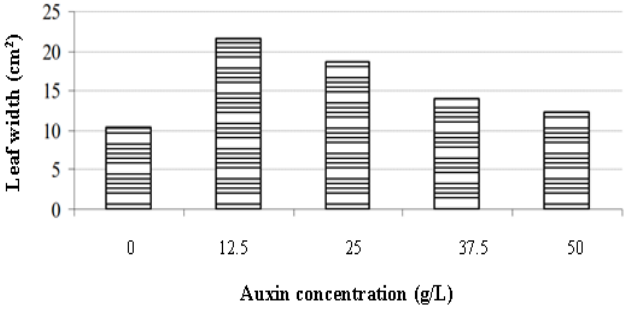

Figure 5. Average pepper leaf width at various concentrations of auxin

Table 2. The average number of pepper roots at various concentrations of auxin (3 months)

Auxin concentration treatment	Number of roots
Without auxin	7.78b
Auxin 12.5 g/L	7.78b
Auxin 25 g/L	3.43ab
Auxin 37.5 g/L	2.33a
Auxin 50 g/L	4ab

Note: Numbers followed by the same letter in one row or column are not significantly different in the Duncan test at the 5% level

Number of roots

Gardner et al. (2017) stated that roots are the main vegetative organs that supply water, minerals, and materials important for plant growth and development. Strong root growth is necessary for shoot strength and growth. Shoot growth will be disrupted if the roots are damaged due to biological, physical, or mechanical disturbances.

Filipović (2020) states that roots function in sucking water and salt-loaded liquids. Another function is to absorb plant nutrients and circulate them to all parts of the plant through the wood network. In addition, it also functions as a plant reinforcement so that its growth is strong. That is why it needs to observe the number of roots in this study.

The media type had no significant effect on the number of roots because the periclinal division determines the number of roots. As stated by Salisbury and Ross (2006), periclinal division, followed by the growth of offspring cells, causes protrusions, namely root primordia.

The data analysis showed that the auxin concentration significantly affected the number of roots (Table 2) because auxin is a growth regulator that stimulates root growth. Although the plant produces natural auxin, providing synthetic auxin from outside can stimulate root growth.

The interaction of media type and auxin concentration based on the results of data analysis showed a very significant effect on the number of roots (Table 2 and Figure 6). Because a planting medium is a place for roots to grow and auxin is a root growth regulator, the combination of the two greatly affects the number of roots. According to Wasito and Nuryani (2005), planting media in soil and organic matter combination provides two advantages: a root growth medium and a source of nutrients and water for root growth.

The highest number of roots was found in soil media treatment with an auxin concentration of 0 g/L (17.67) (Table 3). The second-highest number of roots was found in soil + manure + husk treatment with an auxin concentration of 12.5 g/L (11). The third-highest number of roots was found in soil + manure treatment with an auxin concentration of 12.5 g/L (9). The smallest number of roots was found in the treatment of soil media + manure + husk with an auxin concentration of 25 g/L and soil + manure media with an auxin concentration of 37.5 g/L.

Table 3. The average number of pepper roots on various media and auxin concentrations (3 months)

Media treatment	Auxin concentration (g/L)				
	0	12.5	25	37.5	50
Soil	17.67c	3.33ab	5.67ab	2.33a	4.67ab
Soil+manure	1.67a	9ab	4ab	1a	1.33a
Soil+manure+husk	4ab	11bc	1a	3.67ab	7ab

Note: Numbers followed by the same letter are not significantly different on Duncan's test level of 5%

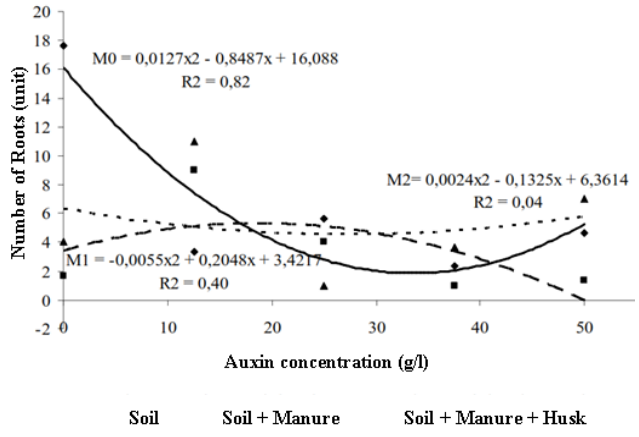

Figure 6. Relationship of the media type and auxin concentration on the number of pepper roots

The number of roots in soil media with auxin concentration of more than 37.5 g/L tends to increase. The determinant coefficient (R2) value is 0.82, meaning that adding auxin affects the number of roots. In soil + manure media, the highest number of roots was found in the treatment with an auxin concentration of 25 g/L. The determinant coefficient (R2) value is 0.40, which means that the effect of giving auxin is weak. On the other hand, in soil + manure + husk media, the least number of roots was found in the treatment with an auxin concentration of 25 g/L. The determinant coefficient (R2) value is 0.04, which means the effect of giving auxin is very weak.

The media type and auxin provision affect the number of roots. In soil media, adding auxin will again increase the number of roots at a concentration of 37.5 g/L (after previously decreasing with the administration of auxin). In soil + manure media, auxin with 12.5 g/L and 25 g/L concentrations will increase the number of roots. However, the higher the auxin concentration applied, the number of roots will decrease. In the medium of soil + manure + husk, adding auxin 25 g/L will increase the number of roots. It indicates an interaction between the type of media and the concentration of auxin on the number of leaves of pepper cuttings seedlings.

The number of roots in soil media showed a parabolic response to the auxin concentration. The number of roots decreased and increased again with increasing auxin concentration. The number of roots in soil + manure and soil + manure + husk with auxin concentration gave the same pattern (close to linear).

The planting medium is an external factor that determines plant growth. For example, the media in the cutting technique functions as a support for cuttings during the root growth period, maintains moisture, and facilitates air penetration. In addition, media with better availability of water and nutrients can stimulate plants to carry out photosynthesis more quickly, producing more photosynthesis, such as increasing the number of roots (Gardner et al. 2017).

Adding auxin increases the number of roots optimally if the concentration is appropriate. Rineksane (2005) stated that using Rootone F (auxin) increases the number of roots. Marlin (2005) states that auxin plays an important role in activating enzymes that make cell components so that once cell division begins, auxin will stimulate the formation of cells quickly. Artanti (2007) stated that auxin has several roles in supporting plant life, one of which is to encourage root primordial.

Root length

Root length results from the elongation of the cells behind the tip meristem. Strong root growth is commonly required for strength and growth (Gardner et al. 2017), while root length is a form of root growth. Genetically, rather than environmentally, mechanisms mainly control the overall shape of the root system, and soil affects it as well (Salisbury and Ross 2006).

The results of the F test showed that the type of media, the concentration of auxin, and the combination of the two had no significant effect on root length. It is because the root is a part of the plant where cell growth and development stages are mostly cell enlargement. In the enlargement of these cells, most water absorption can stretch the walls. The material for the new walls is synthesized so that the walls are not thin. As a result, the wall is widened at the tip at the root, so root growth is more elongated. The supply of external hormones with low concentrations stimulates plant physiological processes, but the response depends on the endogenous hormone level (Salisbury and Ross 2006). So the root length is influenced by the nature of the root, which is more dominant for the increase in root length.

The best root length was found in soil + manure + husk treatment with an auxin concentration of 50 g/L, followed by the same medium with an auxin concentration of 37.5 g/L (Figure 7). It shows that soil + manure + husk media had the best effect on root length because the mixed media of manure and husk can increase plant growth and yield (Zulia and Batubara 2020).

Gardner et al. (2017) also stated that better water availability and nutrients could stimulate plants to make photosynthesis more quickly, producing more photosynthate for roots. Media affects root length because the media is a place where roots grow. Media soil + manure + husk can meet the nutrient needs of plants and provide sufficient space for good root growth. Soil is a natural medium (general), manure provides additional nutrients, and husks provide sufficient space for roots and can bind water.

Salisbury and Ross (2006) added that temperature, aeration, and availability of water and minerals are important factors in root growth. These factors were available in soil + manure + husk media, so this planting medium gave the best results on the growth of pepper cuttings, especially root length. The addition of manures can add nutrients to the growing media while adding husks can improve the structure of the media to make it better (aeration and drainage).

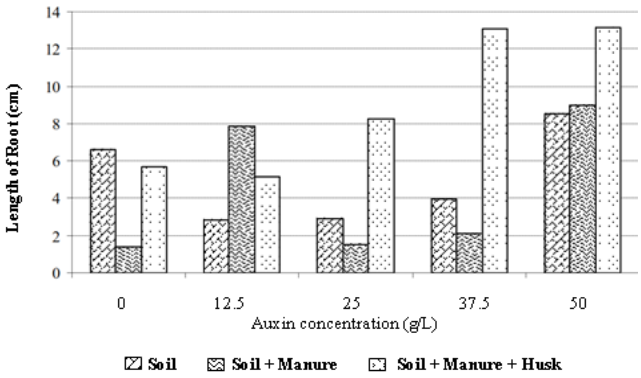

Figure 7. Average root length of pepper on various media and concentration of auxin

Giving auxin can provide better root length because auxin is a growth regulator that stimulates root growth. Especially in soil media, the application of auxin, which increased the number of roots, was a concentration of 50 g/L. In soil + manure media, the addition of auxin was able to increase the number of roots. It is in accordance with Rineksane's study (2005), which states that auxin plays a role in promoting root growth because auxin is a hormone that plays an important role in stimulating root growth. The Rootone F auxin used was formulated by several root growth hormones, so its use is more effective in stimulating roots (Puspitorini 2016).

Percentage of live cuttings

The results of the F test showed that the percentage of live cuttings on several types of media and the concentration of auxin had no significant effect because these seedlings die due to unfavorable weather changes. At the beginning of the nursery, the seedlings experienced good growth (70% humidity). Pepper plants require air humidity between 60-80% (Dewi et al. 2007). In the middle of the study, there were frequent rains, so the humidity of the nursery increased (presumed to be more than 90%) because, in the rainy season, air humidity can reach more than 90%.

In addition, this simple tool in the nursery is a bit annoying during the rainy season. The rainwater that fell wet the paranet, then hit the dried coconut leaves used to cover the plastic which covered the seedlings. As a result, coconut leaves as a cover become heavier, and a lot of water is poured on the plastic, which causes the surface of the plastic to lower and touch the already tall seedlings.

Then the pepper cuttings are left exposed but still in paranet shade to reduce moisture and further damage. However, after the seedlings are left open, environmental influences also affect the growth of the seedlings, including disease. Plants that had been disturbed due to the disruption of the covering apparatus slowly began to improve with the emergence of new shoots. However, some still cannot improve because of the damages that cause the stems to rot.

The type of media treatment and auxin concentration interacted with the percentage of live cuttings (Table 4). The success of pepper seedlings is quite high, as seen from the number of cuttings that live at the end of the observation. Overall there were 93.33% live cuttings, namely 42 of 45 seedlings.

Control media gave better results in the percentage of live cuttings than other media. The use of soil media was able to produce an average percentage of live cuttings of 100% at all auxin concentrations. Soil media + manure + husk at a concentration of 50 g/L auxins gave the percentage of live cuttings of 66.67%. Soil media + manure at a concentration of auxin 25 g/L gave the percentage of live cuttings of 33.33%. This result shows that soil media has the highest percentage of live cuttings.

Soil media-only is better than other combined media, such as soil media + manure or soil media + manure + husk. It is presumably due to the influence of the external/surrounding environment that affects the media and ultimately affects the pepper-cutting seedlings. However, this external environment can also directly affect the pepper cuttings seedlings' condition. So the pepper cuttings get two influences, namely from the outside environment and the planting medium.

Soil media is a commonly used and natural medium for all plants. However, if this media is exposed to continuous/large-intensity rainwater, it will cause the media to become saturated with water. Meanwhile, the soil + manure, which contains a lot of organic matter, will become very humid if continuously exposed to rainwater and can grow unexpected things such as pathogens. The same applies to soil + manure + husk, but there is also a husk with less manure. Therefore, it causes the percentage of live cuttings in soil + manure + husk media to be higher than soil + manure media, although it is still lower than soil media.

The percentage of live cuttings reached 93.33%, indicating that the ability of the cutting material to grow and develop is high. It means that the cutting material contains meristematic tissue that is actively dividing. Marlin (2005) stated that meristematic tissue that is actively dividing could grow and develop quite high (83.33-100%). So even though the percentage of auxin in this study did not reach 100%, it could be said to be quite high. Although the percentage of live cuttings was more influenced by the external environment than the effect of auxin administration, the analysis showed an interaction between the media and auxin treatment.

Table 4. The average percentage of live pepper cuttings on various media and auxin concentration (%)

Type of media	Auxin concentration (g/L)				
Soil	0	12.5	25	37.5	50
Soil+manure	100a	100a	33.33b	100a	100a
Soil+manure+husk	100a	100a	100a	100a	66.67ab

Note: Numbers followed by the same letter in one row or column are not significantly different in the Duncan test at the 5% level

The percentage of live cuttings in the auxin treatment was lower than the control (without auxin). It differed from Amirudin et al. (2004), who stated that synthetic PGR increased the percentage of live cuttings of pepper shrubs. It happened because the influence of the environment was at large on the percentage of live cuttings, so the unfavorable environment caused the percentage of live cuttings to be low.

The following conclusions can be drawn based on the results: (i) The best growth of pepper cuttings on shoot length was obtained in soil + manure + husk (12.28 cm) media. (ii) The growth of pepper cuttings was affected by PGR (auxin). The best concentration of auxin at shoot length (15.14 cm) and several roots (7.78) was 12.5 g/L. (iii) The interaction between the planting medium and the provision of auxin on the growth of pepper cuttings seedlings occurred in the number of roots and the percentage of live cuttings. The number of roots in soil media showed a parabolic response to the auxin concentration. The number of roots decreased and increased again by increasing auxin concentration. The number of roots in soil + manure and soil + manure + husk with auxin concentration gave the same pattern (close to linear). Most of the media produced a percentage of 100% live cuttings with the auxin addition. Still, in soil + manure with an auxin concentration of 25 g/L and soil + manure + husk with an auxin concentration of 50 g/L, the live cuttings were equal to 33.33% 66.67%, respectively.

REFERENCES

Adnan, Basri AB, Azis A, Idawanni, Iswoyo H. 2021. Application of coffee husk compost and EM4 on growth and yield of chili pepper (*Capsicum frutescens* L.). 2021. IOP Conf Ser Earth Environ Sci 807: 042040.

Adugna G. 2016. A review on impact of compost on soil properties, water use and crop productivity. Agric Sci Res J 4 (3): 93-104. DOI: 10.14662/ARJASR2016.010.

Amirudin, Supartoto, Faozi K. 2004. Pengaruh beberapa jenis ZPT sintesis terhadap pertumbuhan stek lada perdu (*Piper nigrum* L.). Agrin 8 (1): 19-24. [Indonesian]

Artanti FY. 2007. Pengaruh Macam Pupuk Organik Cair dan Konsentrasi IAA terhadap Pertumbuhan Setek Tanaman Stevia (*Stevia rebaudiana* Bertoni M.). [Hon. Thesis]. Universitas Sebelas Maret, Surakarta. [Indonesian].

Azahari DH, Purba HJ, Erwidodo, Darwis V, Dabukke FBM, Hestina J, Yusuf ES. 2021. The competitiveness of Indonesia's pepper export and its challenges. IOP Conf Ser Earth Environ Sci 892: 012074. DOI: 10.1088/1755-1315/892/1/012074.

Dewi O, Nurawan A, Hanafiah A, Budiman, Sediono D, Saragih D. 2007. Petunjuk Teknis Pembibitan Lada Perdu. http://ditjenbun.deptan.go.id. [Indonesian]

Dewi SS, Sabhara SA. 2022. The effect of natural PGR combination on the growth of fig (*Ficus carica* L.) plant cuttings. IOP Conf Ser Earth Environ Sci 985: 012019. DOI: 10.1088/1755-1315/985/1/012019.

Filipović A. 2020. Water plant and soil relation under stress situations. In: Meena RS, Datta R (eds). Soil Moisture Importance. IntechOpen, London. DOI: 10.5772/intechopen.93528.

Gardner FP, Pearce RB, Mitchell RL. 2017. Physiology of crop plants. 2nd ed. Scientific Publishers, Jodhpur, India

Jayusman. 2005. Perbanyakan gaharu melalui stek. J Penelitian Hutan Tanaman 2 (3): 117-124. DOI: 10.20886/jpht.2005.2.3.117-124. [Indonesian]

Marlin. 2005. Regenerasi in vitro planlet jahe bebas penyakit layu bakteri pada beberapa taraf konsentrasi BAP dan NAA. J Ilmu-Ilmu Pertanian Indonesia 7 (1): 8-14. [Indonesian]

Olatunji D, Geelen D, Verstraeten I. 2017. Control of endogenous auxin levels in plant root development. Intl J Mol Sci 18 (12): 2587. DOI: 10.3390/ijms18122587.

Puspitorini P. 2016. The sources of auxin hormone to growth of shoot pineapple stem cutting (*Ananas comosus* L. Merr.). Jares 1 (1): 45-52. DOI: 10.30957/jares.v1i1.41.

Ren T, Weraduwage SM, Sharkey TD. 2018. Prospects for enhancing leaf photosynthetic capacity by manipulating mesophyll cells morphology. J Exp Bot 70 (4): 1153-1165. DOI: 10.1093/jxb/ery448.

Rineksane IA. 2005. Pengaruh lama perendaman biji dalam auksin terhadap perkecambahan dan pertumbuhan akar manggis. J Ilmu-Ilmu Pertanian Agr UMY 13 (2): 83-91. [Indonesian]

Sairanen I, Novák O, Pěnčík A, Ikeda Y, Jones B, Sandberg G, Ljung K. 2012. Soluble carbohydrates regulate auxin biosynthesis via PIF proteins in *Arabidopsis*. Plant Cell 24: 4907-4916. DOI: 10.1105/tpc.112.104794.

Salisbury FB, Ross CW. 2006. Plant Physiology 4th Edition. CBS Publishers & Distributors, New Delhi.

Sitompul SM, Guritno B. 1995. Analisis Pertumbuhan Tanaman. UGM Press, Yogyakarta. [Indonesian]

Sopialena, Suyadi, Sahil M, Nurdiana J. 2018. The diversity of endophytic fungi associated with *Piper nigrum* in the tropical areas: a recent study from Kutai Kartanegara, Indonesia. Biodiversitas 19: 2028-2034. DOI: 10.13057/biodiv/d190607.

Sutedjo MM. 1990. Analisis Tanah, Air dan Jaringan Tanaman. Rineka Cipta, Jakarta. [Indonesian]

Tian H, Niu T, Yu Q, Quan T, Ding Z. 2013. Auxin gradient is crucial for the maintenance of root distal stem cell identity in *Arabidopsis*. Plant Signal Behav 8: e26429. DOI: 10.4161/psb.26429.

Wasito A, Nuryani W. 2005. Dayaguna kompos limbah pertanian berbahan aktif cendawan *Gliocladium* terhadap dua varietad krisan. J Hortic 15 (2): 97-101. [Indonesian]

Zulia C, Batubara S. 2020. Application of rice husk and chicken manure to the growth and production of red spinach (*Amaranthus gangeticus* L.). Intl J Mult Sci 1: 58-68.