Jurnal Pembelajaran Dan Biologi Nukleus
Vol 9 (2): 201-218, July 2023

p-ISSN: 2442-9481
e-ISSN: 2685-7332

Invasion Of Endophytic Bacteria By Using Microencapsulation Technology As Stimulant in Cocoa Plants (*Theobroma cacao* L)

Gusti Yanda Prayoga, Kabul Warsito(*), Hanifah Mutia Z.N. Amrul
Department of Agrotetechnology, University of Pembangunan Panca Budi,
Jl. Gatot Subroto km, 4.5, Medan, Indonesia
***Corresponding author**: kabulwarsito@dosen.pancabudi.ac.id

Submitted February 08th 2023 and Accepted May 02nd 2023

Abstract

*Fertilization is an important process in the growth of cocoa (*Theobroma cacao *L). Fertilizing cocoa usually used inorganic fertilizers. Using of inorganic fertilizers continuously could degrading soil fertility. One of efforts to replace inorganic fertilizers was using endophytic bacteria as biofertilizers. Some endophytic bacteria are abundant in healthy plant tissues. The aim of this research was to obtain endophytic auxin-producing bacteria in cocoa plants and determine effect of seed immersion and microcapsules addition of endophytic bacteria on cocoa plant growth. Research design used was Complete Randomized Design (CRD), 16 treatments and 3 replications. First factor was immersion of cocoa seed using endophytic bacteria suspension consisting of S0= 0 hours; S1= 5 hours; S2= 6 hours and S3= 7 hours and second factor was microcapsules addition consisting of B0= 0 gr; B1= 5 gr; B2= 10 gr; B3= 15 gr. Isolation from roots and stems cocoa obtained 5 isolates endophite bacteria. Auxin assays showed that five isolates were able produced auxin. Observations on plant height showed best treatment was treatment B1 (32.49 cm). Observation total leaves showed S3 treatment was highest data (11.83 strands). Observation rod diameter parameter, highest data was S3 treatment (4.01 mm). For leaf area parameter, highest value was B1 treatment (66.64 cm^2). For wet weight parameter, highest data was S3 treatment (18.41 g). Root length parameter, highest data was B3 treatment (15.78 cm). Test results showed that application of suspension and microcapsules endophytic bacteria significantly increased growth of cocoa.*

Keywords*: Auxin, Cocoa, Endophytic Bacteria, Microcapsules*

https://doi.org/10.36987/jpbn.v9i1.3815

INTRODUCTION

Cocoa (*Theobroma cacao* L) is one of plantation commodities that are suitable for community also has considerable potential in increasing foreign exchange, and as a source of livelihood of farming families scattered in various provinces in Indonesia (Dekaindo, 2016). Cocoa cultivation can be done generatively by using cocoa beans. During breeding process, things to consider in cocoa cultivation was fertilization for fertility or plant health and productivity. Fertilizers commonly used in fertilization process was usually inorganic (chemical) fertilizers to increase production and quality of cocoa plants (Sriharti & Dyah, 2018).

p-ISSN: 2442-9481
e-ISSN: 2685-7332

According to Sabahannur et al., (2016) cocoa cultivation with inorganic fertilizer caused 90% of cocoa beans produced became low quality. Continuous use of inorganic fertilizers can also increase soil fertility, even changing physical, chemical and biological properties of soil (Maghfoer, 2018). Increase productivity due to use of inorganic fertilizers lasts only a short time and was not sustainable.

One of effort to increase cocoa production was using biofertilizer (Arifah et al., 2018). Application of biofertilizers and organic fertilizers in seedling phase was also necessary (Krisdayani et al., 2020). Biological fertilizer was microbes given into soil to increase nutrient uptake by plants from within land. This fertilizer contains superior soil microorganisms and it was useful to increase soil fertility as a result of soil biochemical processes.

One of innovations in biofertilizers is using of endophytic bacteria. Some excess endophytic bacteria are abundant in healthy plant tissue. Research (Puspita et al., 2019) reported that endophytic bacteria can be taken from almost all parts of plants. Foeh et al., (2019) mentioned that advantages of endophytic bacteria some of which was also able to increase plant growth. Saridewi et al., (2020) also reported endophytic bacteria had ability produced phytohormones such as auxin, increase phosphate availability, produced various enzymes such as amylase, selluase. Endophytic bacteria were also thought to be able to increase plant defense system against plant disease disorders due to their ability to produce antimicrobial compounds, enzymes, salicylic acid, ethylene and other secondary compounds (Sihombing, et al., 2019).

This research purposed to obtain isolates of endophytic bacteria from cocoa roots and stems, determine their ability to produce the auxin hormone and test their effectiveness in stimulating cocoa growth. Results of this study are expected to be useful as a reference and guidance for further research.

METHOD

Tools and Materials

Tools used in this study were petri dishes, test tubes, test tube racks, measuring cups, beakers, erlenmeyer, autoclaves, oven, spatulas, ose needles, incubators, hot plates, stirring rods, analytical scales, sprayers, laminar airflow, shakers, glass bottles, aluminium foil, cotton, cutter and polybag.

Materials used in this study are roots and stems of cacao, nutrient media Agar (NA), aquadest, alcohol 70%, chlorine solution, $CaCl_2$, sodium alginate, inulin, poultry manure, top soil, rice husk charcoal, NaCl 0,9%, crystal violet, safranin, acetone alcohol, iodine, L-tryptopan, peptone, Salkowsky reagent.

Research Methods

This research was conducted using factorial CRD (Complete Randomized Design) method consisting of 2 factors, 16 treatments and 3 replications. Suspension immersion consists of: S0: 0 hour; S1: 5 hours; S2: 6 hours and S3: 7 hours. Microcapsule addition treatment consists of B0: 0 gr, B1: 5 gr; B2: 10 gr, B3: 15 gr. Data obtained were analyzed using ANOVA. Results of analysis were followed by Duncan's test.

Isolation of Endophytic Bacteria

Endophite bacteria was isolated from cacao roots and stems. Isolation of endophite bacteria used method (Singh et al., 2022) modified. Before isolation process, surface of roots and stems of cocoa was sterilized.

Measurement of Auxin From Endophytic Bacteria

Auxin testing conducted according to (Walida et al., 2019) which has been modified. Isolates were inoculated on flat Nutrient Agar media supplemented with tryptophan at concentration of 100 ppm and incubated at room temperature for 48 hours. Salkowski reagent was dripped onto endophite bacterial colonies. Colonies that had been dripped with Salkowski reagent was stored in dark room for 30 minutes. Positive result was indicated by a change in color of colonies became red (Herlina et al., 2017).

Preparation and Sterilization of Planting Media

Planting media used top soil, broiler manure and rice husk charcoal with a ratio (1: ½ : ½). Sterilization was carried out at 150^{0}C for 10 hours.

Immersion Seeds with Suspension of Endophite Bacteria

Collection of endophite bacteria solution was carried out by adding 10 ml of NaCl 0,9% solution in 1 petri, and stirring using a triangular stir bar. Cacao seeds were soaked at ratio: 0 hours, 5 hours, 6 hours and 7 hours in a container covered with aluminum foil to keep it sterilized.

Producing of Microcapsules From Endophite Bacteria As Biofertilizers

Total of 14.7 g of $CaCl_2$ was dissolved with 1000 ml of distilled water in a volumetric flask, stirred until homogeneous. Solution was sterilized using autoclave at 121°C for 15 minutes. Sterile alginate solution containing suspension of endophite bacteria was put into a spit needle and then dropped into 0.1M $CaCl_2$ solution. To remove $CaCl_2$ residue, microcapsule was filtered and rinsed using distilled water (Panichikkal et al., 2021).

Application of Microcapsules

Application of microcapsule bacterial fertilizers was carried out in 2nd week after planting (WAP) plant shoots appear or when leaves appear with dose of predetermined treatment level.

Observation Parameters

Parameters observed in this research were plant height (cm), total of leaves (strands), stem diameter (mm), average leaf area (cm^2), wet weight of plants (g), root length (cm).

RESULTS AND DISCUSSION

Isolation of Endophytic Bacteria From Roots And Stems of Cocoa Plants

Isolates of endophytic bacteria from roots and stems of cocoa plants (*Theobroma cacao* L) obtained 5 isolates consisting of 2 isolates samples from cocoa stems and 3 isolates from cocoa roots. Each isolate had characteristics that vary in both morphology and coloring properties.

Table 1. Colony and cell morphology and gram staining properties of endophytic bacterial isolates of cacao roots and stems (*Theobroma cacao* L).

Isolate	Characterization						Gram
	Morphology Colony				Cell Morphology		
	Color	Shape	Edge	Elevation	Shape	Setup	
GS1 BK	White	Irregulr	Irregulr	Placocoau	Basil	Mono	Positive
GS2 BK	White	Rhizoid	Lobate	Flat	Basil	Strepto	Negative
GS1 AK	White	Round	Irregulr	Flat	Basil	Strepto	Positive
GS2 AK	White	Irregulr	Irregulr	convex	Basil	Strepto	Positive
GS3 AK	White	Rhizoid	Lobate	margin	Coccus	Strepto	Negative

Ability of Endophytic Bacteria From Roots and Stems of Cocoa Plants in Producing Auxin Hormone

Isolation results of endophytic bacteria, 5 isolates produced auxin hormones were marked with changes in transparent red and pink colors when dripped Salkowski reagent. Results of auxin hormone levels from root and stem endophytic bacteria were showed in Table 2.

Table 2. Auxin hormone rate produced by endophytic bacteria from roots and stems of cocoa plant (*Theobroma cacao* L).

Isolates	Auxin Rate
GS1 BK	+
GS2 BK	+
GS1 AK	+
GS2 AK	+
GS3 AK	+

Plant Height (cm)

Cocoa plant height was observed at week 2, 4, 6, 10 weeks after planting (WAP). Based on results of observations and ANOVA test, it was known that immersion treatment of cocoa plant height growth (*Theobroma cacao* L) had no significant difference in plant height (cm) on observations of 2^{nd} WAP, 4^{nd} WAP, 6^{nd} WAP, 8^{nd} WAP, and had a markedly different influence on 10^{nd} WAP. Addition of microcapsules had no significant difference on plant height at observation of 2^{nd} WAP, 4^{th} WAP, 6^{th} WAP, 8^{th} WAP, but giving a noticeable difference in observation at 10^{th} WAP.

Interaction of influence of variations in immersion and microcapsule addition had unreal effect on measurement data of plant height (cm) on growth of cocoa plants (*Theobroma cacao* L). Duncan Distance test results were showed in Table 1.

Table 3. Average Height Cocoa (*Theobroma cacao* L) by Immersion Treatment And Microcapsule Addition.

Treatment	Average Plant Height (cm)				
	2nd WAP	4th WAP	6th WAP	8th WAP	10th WAP
Immersion Treatment (S)					
S0 = 0 Hours	13.61 aA	20.49 aA	22.27 aA	24.35 aA	27.55 bA
S1 = 5 hours	13.42 aA	22.79 aA	25.68 aA	27.89 aA	31.84 aA
S2 = 6 hours	12.75 aA	20.46 aA	24.60 aA	26.64 aA	30.98 aA
S3 = 7 hours	13.25 aA	20.41 aA	23.71 aA	27.88 aA	31.22 aA
Microcapsule Addition (B)					
B0 = 0 gr	13.80 aA	19.98 aA	23.35 aA	26.30 aA	29.78 aA
B1 = 5 gr	13.38 aA	20.85 aA	23.89 aA	27.35 aA	32.49 abA
B2 = 10 gr	12.21 aA	21.21 aA	24.07 aA	27.43 aA	30.68 abA
B3 = 15 gr	13.64 aA	22.11 aA	24.95 aA	25.68 aA	28.64 aA

Total of Leaves (strands)

Total of leaves were observed at 2nd, 4th, 6th, 8th, 10th week after planting (WAP). Based on results of observations and ANOVA test, it was known that observation on total of leaves of cocoa plant (*Theobroma cacao* L) had unreal influence on the observation of 2nd WAP, 4th WAP, and 10 WAP. Observation on 6th WAP, and 8th WAP had very noticeable different influence on total of leaves (strands). However, it had an unreal influence on treatment of microcapsules addition at 2nd WAP, 4th WAP, 6th WAP, 8th WAP, 10th WAP. Interaction of influence of variations in immersion and addition of microcapsules had no real effect. Duncan test results were showed in Table 4.

Table 4. Average total of leaves cocoa (*Theobroma cacao* L) by immersion and microcapsule addition.

Treatment	Average Total of Leaves (strands)				
	2nd WAP	4th WAP	6th WAP	8th WAP	10th WAP
Immersion (S)					
S0 = 0 Hours	3.92 aA	5.17 aA	6.92 bcA	9.00 bB	11.08 aA
S1 = 5 hours	4.08 aA	5.67 aA	6.92 bcA	8.50 bB	11.08 aA
S2 = 6 hours	3.58 aA	5.17 aA	6.92 bA	8.75 bB	10.75 aA
S3 = 7 hours	4.17 aA	6.08 aA	7.92 aA	10.42 aA	11.83 aA
Microcapsule Addition (B)					
B0 = 0 gr	4.33 aA	5.50 aA	7.17 Aa	5.75 aA	11.75 aA
B1 = 5 gr	3.92 aA	5.58 aA	7.25 aA	5.75 aA	11.75 aA
B2 = 10 gr	4.00 aA	5.58 aA	6.83 aA	5.75 aA	10.75 aA
B3 = 15 gr	3.50 aA	5.42 aA	7.42 aA	5.63 aA	10.50 aA

Table 5. Average treatment of interaction of immersion and microcapsule addition on total of leaves cocoa (*Theobroma cacao* L).

Treatment	Average Number of Leaves (strands)	
	6^{th} WAP	8^{th} WAP
S0B0	7 ^{bcdCD}	9 ^{bcdeBCDE}
S0B1	6.67 ^{cdD}	9 ^{bcdeBCDE}
S0B2	7.67 ^{bcBC}	9.33 ^{bcdeBCD}
S0B3	6.33 ^{dD}	8.66 ^{cdefCDE}
S1B0	7 ^{bcdCD}	8.33 ^{defDEF}
S1B1	7.67 ^{bcBC}	10 ^{bcB}
S1B2	6.33 ^{dD}	7.33 ^{fF}
S1B3	6.67 ^{cdD}	8.33 ^{dcfDEF}
S2B0	6.67 ^{cdD}	9 ^{bcdeBCDE}
S2B1	8 ^{bB}	9.66 ^{bcdBC}
S2B2	6.33 ^{dD}	8 ^{efDF}
S2B3	6.67 ^{cdD}	8.33 ^{dcfDEF}
S3B0	8 ^{bB}	10 ^{bcB}
S3B1	6.67 ^{bB}	8.33 ^{dcfDG}
S3B2	7 ^{bB}	10 ^{bB}
S3B3	10 ^{aA}	13 ^{aA}

Based on observations from Table 4. showed that interaction of average amount of leaves from immersion treatment and addition of endophytic bacterial microcapsules had a markedly different influence on 6^{th} WAP after being tested using Duncan Distance Test.

Rod Diameter (mm)

Based on results of observations and ANOVA test, it was known that effect of immersion and microcapsules addition on cocoa growth (*Theobroma cacao* L) has unreal different influence on diameter of plant stem on observations to 2^{th} WAP, 4^{th} WAP, 6^{th} WAP, 8^{th} WAP, and was very real on observations of 10^{th} WAP.

Interaction effect of bacterial suspension immersion and microcapsule addition had unreal effect on measurement data of stem diameter (mm) on cocoa growth (*Theobroma cacao* L) after being tested using Duncan test were showed in Table 6.

 p-ISSN: 2442-9481
e-ISSN: 2685-7332

Table 6. Average diameter of stem cocoa (*Theobroma cacao* L) by immersion and microcapsules addition.

Treatment	Average Diameter of the Plant Stem (mm)				
	2ndWAP	4thWAP	6thWAP	8thWAP	10thWAP
Immersion (S)					
S0 = 0 Hours	2.66 aA	2.86 aA	3.09 aA	3.40 aA	3.71 bB
S1 = 5 hours	2.75 aA	2.96 aA	3.19 aA	3.53 aA	3.83bAB
S2 = 6 hours	2.86 aA	3.09 aA	3.35 aA	3.61 aA	3.92abAB
S3 = 7 hours	2.86 aA	3.05 aA	3.23 aA	3.70 aA	4.01 aA
Microcapsule Addition (B)					
B0 = 0 gr	2.84 aA	3.03 aA	3.27 aA	3.59 aA	3.91 aA
B1 = 5 gr	2.87 aA	3.08 aA	3.32 aA	3.66 aA	3.99 abA
B2 = 10 gr	2.74 aA	2.95 aA	3.16 aA	3.55 aA	3.88 abA
B3 = 15 gr	2.68 aA	290 aA	3.11 aA	3.43 aA	3.70 aA

Table 7. Average interaction treatment of immersion and microcapsules addition on stem diameter of cocoa plant (*Theobroma cacao* L).

Treatment	Average Diameter of Plant Stem (mm)
S0B0	3.73 efgEF
S0B1	3.97 abcdeABCD
S0B2	3.56 Gg
S0B3	3.58 fgFG
S1B0	3.86 deCDE
S1B1	4 abcdABC
S1B2	3.94 abcdeCD
S1B3	3.52 gG
S2B0	3.90 cdeCDE
S2B1	4.12 abcAB
S2B2	3.86 deCDE
S2B3	3.79 deDE
S3B0	4.13 abA
S3B1	3.86 deCDE
S3B2	4.14 aA
S3B3	3.92 abcdeCDE

Based on observations from Table 7 showed that average interaction of stem diameters from immersion and microcapsules addition of endophytic bacterial microcapsules had a different influence on 10th weeks after planting (WAP) used Duncan test.

Leaf Area (cm²)

Leaf area was observed at 10th weeks after planting (WAP). Based on results of observations and ANOVA test, it was known that of immersion and microcapsules addition of leaf area on cocoa plant (*Theobroma cacao* L) had unnoticeable different influence on leaf area at observation of 10th WAP.

Table 8. Average leaf area of cocoa plant (*Theobroma cacao* L) against of immersion and microcapsules addition.

Treatment	Leaf Area (cm^2)
Immersion (S)	
S0 = 0 Hours	54.21 aA
S1 = 6 hours	58.25 Aa
S2 = 7 hours	74.71 aA
S3 = 8 hours	65.77 aA
Microcapsule Addition (B)	
B0 = 0 gr	63.94 aA
B1 = 5 gr	66.64 aA
B2 = 10 gr	61.79 aA
B3 = 15 gr	60.57 aA

Plant Wet Weight (g)

Based on Duncan test results on plant wet weight parameter of cocoa (*Theobroma cacao L*), immersion treatment showed different very markedly and on the microcapsules addition got markedly different results and on interaction process got a real difference. Interaction of bacterial suspension immersion effect and microcapsule addition had a marked effect on plant wet weight measurement data (g) on cocoa growth.

Table 9. Average plant wet weight of cocoa plants (*Theobroma cacao* L) of immersion and microcapsules addition.

Treatment	Wet weight of the plant (g)
Immersion (S)	
S0 = 0 Hours	12.64 dD
S1 = 5 hours	15.96 cC
S2 = 6 hours	18.25 bB
S3 = 7 hours	18.41 aA
Microcapsule Addition (B)	
B0 = 0 gr	10.97 aA
B1 = 5 gr	11.53 aA
B2 = 10 gr	10.18 aA
B3 = 15 gr	9.89 aA

Table 10. Average interaction treatment of of immersion and microcapsules addition in plant wet weight of cocoa plants (*Theobroma cacao* L).

Treatment	Average wet weight of the plant (g)
S0B0	72.61 ^{mM}
S0B1	12.25 ^{dD}
S0B2	58.81 ^{No}.
S0B3	59.49 ^{No}.
S1B0	11.96 ^{gG}
S1B1	10.84 ^{jJ}
S1B2	12.09 ^{eE}
S1B3	67.81 ^{nN}
S2B0	11.21 ^{fF}
S2B1	14,4 ^{aA}
S2B2	10,89 ^{hH}
S2B3	99.56 ^{kK}
S3B0	13.84 ^{bB}
S3B1	10.29 ^{iI}
S3B2	91.09 lL
S3B3	13.61 cC

Based on observations from Table 10 showed that average plant wet weight interaction of immersion and microcapsules addition of endophytic bacterial microcapsules had markedly different effect after being tested using Duncan test.

Root Length (cm)

Based on results of observations and ANOVA test, it was known that effect of immersion and microcapsules addition of endophytic bacteria on cocoa growth (*Theobroma cacao* L) had different influence on the immersion and had noticeable difference in treatment of capsule microcapsules addition. Interaction effect of bacterial suspension immersion and microcapsules addition had unreal effect on root length measurement data (cm) on cocoa growth.

Table 11. Average roots length of cocoa plants (*Theobroma cacao* L) by immersion and microcapsules addition.

Treatment	Root length (cm)
Immersion (S)	
S0 = 0 Hours	14.37 ^{aA}
S1 = 5 hours	14.02 ^{aA}
S2 = 6 hours	13.72 ^{aA}
S3 = 7 hours	14.40 ^{aA}
Microcapsule Addition (B)	
B0 = 0 gr	12.96 ^{Ba}
B1 = 5 gr	14.34 ^{abA}
B2 = 10 gr	13.43 ^{abA}
B3 = 15 gr	15.78 ^{aA}

p-ISSN: 2442-9481
e-ISSN: 2685-7332

Discussion

Isolation of Endophytic Bacteria From Roots and Stems of Cocoa (*Theobroma* cacao L)

Cocoa plants had diversity of endophytic bacterial isolates. Auxin hormone-producing endophytic bacterial isolated from cacao plants (*Theobroma* cacao L) had different characteristics such as irregular, rhizoid, round, lobate, plancocoau, flat, conrex, margin, bacil, coccus, mono, strepto. Cocoa plants had diversity of endophytic bacterial produced auxin hormones isolated from cocoa plants (*Theobroma cacao* L). These isolates dominant from genus of *Bacillus*. Salo & Novero, (2020) reported that plants of same type or species have endophytic bacteria that are not always same. Research (Giyanto & Anwar Arifin, 2019) reported that isolates of endophytic bacteria isolated from cocoa plants could spur growth of cocoa plants.

Test Potential of Endophytic Bacteria of Cocoa Plants In Producing Auxin

Based on results test there are 5 isolation of bacteria derived from roots and stems of cocoa plants, produced auxin hormones. Previous researchers have proven that physiological improvement of plant seeds and plant growth retardation by addition of endophytic bacteria or other microbial groups were related to the ability of microbes to increase nitrogen fixation, auxin production, and phosphate dissolving ability as per research (Khaeruni et al., 2020). Ability of microbes produced auxin was also influenced by type of microorganism species. From results of isolation *Bacillus* was most dominant. This was suspected because *Bacillus* sp. derived from plants produced auxin for plant growth. Results of analysis (Puspita et al., 2019) showed that 4 isolates of *Bacillus* sp. endophytic produces hormone auxin, which was characterized by formation of a pink. Same microorganism was not necessarily able to produce same auxin (Saputri et al., 2020).

Plant Height (cm)

Results of plant height parameter obeservation of cocoa (*Theobroma cocoa* L), highest data at 10th WAP in S1 (31.84) cm and addition of microcapsules at 10th WAP in B1 (32.49 cm). These results was better than research (Warsito et al., 2022) showed application of chicken manure to plant heights , where the plant height at A1 (200g) was 23.20 cm and at A0 (control) it was 21.65 cm. Addition of coconut water showed different plant heights where plant height at K2 (200 ml / polybag) was 22.80 cm, K1 (100 ML/ polybag) 22.44 cm and K0 (control) 22.03 cm. In another research (Jamidi et al., 2021) reported that in pineapple peel liquid organic fertilizer activities with a concentration of 75 ml/ L, which showed highest plant height (31.97 cm). While in cow manure equipment, best dosage level was dose of 10 tons/ ha which showed value of plant height (32.32 cm). This research was also better than research (Aulia Meyuliana et al., 2022) that best equipment was 350 g/ polybag (cattle dirty cleaner) equipment with a value (25.06 cm). Research (Marwan et al., 2021) showed that endophytic bacteria was able to trigger plant height, in rice plant research. (Pradana et al., 2020) reported that tomato plants inoculated with endophytic bacteria were able to significantly increase height of different tomato plants compared to controls. (Prihatiningsih et al., 2021) also reported that endophytic bacteria directly promote plant growth including plant height and indirectly control pathogens.

Total of Leaves (strands)

Observation total of leaves cocoa plants (*Theobroma cacao* L) showed that immersion treatment had highest yield of 6th WAP S3 (7.92 strands). Observation on 6th WAP showed that best yield on interaction in immersion (S3) and microcapsule addition B3 (10 strands). Observation on 8th WAP showed that best data on interaction treatment S3 and B3 (13.33 strands). This result was better than research (Aulia Meyuliana et al., 2022) with highest average number leaves found with a dose 25ml (liquid organic fertilizer from a mixture of tomato extract, coconut water and rice washing water) of 4.88 and lowest number leaves found in control of 3.25. (Ariana, 2016) reported that tobacco plants treated with endophytic bacteria were able to increase number tobacco leaves more than control plants.

Stem Diameter (mm)

Observation on stem diameter of cocoa plant growth (*Theobroma cacao* L), best results were found at 10th WAP in immersion treatment S3 (4.01 mm) and microcapsule addition B1 (3.99 mm). Interaction treatment showed that best results was immersion treatment S3 and microcapsule addition B2 (4.14 mm). Results of this research was better than (Aulia Meyuliana et al., 2022) with addition of 25 ml (liquid organic fertilizer derived from a mixture of tomato extract, coconut water and rice washing water) gave highest average (0.41 mm). This research was also better compared (Aulia Meyuliana et al., 2022) with highest amount found in treatment of liquid tofu waste (80 ml/polybag) with an average (3.61 mm) and lowest in treatment of liquid tofu waste (60 ml/polybag) with an average (3.25 mm). (Permadi, 2021) reported biological agents auxin producing-endophytic bacteria that served to spur plant stem growth. (Herlina et al., 2016) reported endophytic bacteria provided essential nutrients such as nitrogen, phosphorus, and other minerals, as well as growth hormones such as auxin, ethylene, and cytokinin by producing growth hormones including auxin, cytokinin, and peptide N synthase. Endophytic bacteria had ability to bind nitrogen, but some researchers reported that increase in plant growth was more in ability of microbes to produce growth regulators in form of hormones such as gibberellin (Zain et al., 2018).

Leaf Area (cm^2)

Best results of observation on 10th WAP by addition of microcapsules was B1 treatment (66.64 cm^2) and for seed immersion best result was showed by S3 treatment (65,77cm^2). This result was better than research (Yusuf et al., 2018) that highest yield of leaf area was found in 80% of soil layer :15% cow dung : 5% sand with an average of 56.11cm^2. (Putri et al., 2016) reported that auxin produced by endophytic bacteria was known to spur the growth of cocoa seedlings compared to controls. Auxin produced by bacteria would be utilized by plants and passed metabolic processes in plant organ so that it could help growth process of cocoa seedlings extensively.

Plant Wet Weight (gr)

Observations of plant wet weight on cocoa (*Theobroma cacao* L) showed best result was in treatment S3 (18.41 g) for seed immersion and for addition of microcapsules was B1 treatment (11.97 g). Interaction of immersion treatment (S2) and microcapsule additon (B3) showed as best result (99.56 g). This results was better than (Aulia Meyuliana et al., 2022) used treatment of 350g/ polybag on cocoa (goat manure fertilizer) with highest value 14.13 g. This results also better than research (Usrin, U., Pamungkas, D. H., & Widata, 2019) used dose of 10 L liquid organic fertilizer and highest manure soil ratio of 1 : 1 with highest data 14.59 g. Results of this research support results of previous research that rubber plants treated with endophytic bacteria had significantly different wet and dry weights compared to controls (Moshinsky, 2020). This research was accordance with (Marwan et al., 2021) used treatment of endophytic bacteria on rice seedlings was also able suppressed severity of bacterial leaf blight by 76.17 to 86.61%, and had effect on plant height, total of saplings, total of panicles, grain weight contained and was able reduced percentage of empty grains . Therefore, it was also believed that increase in growth of cocoa seedlings significantly different than control treatment in this research was caused by immersion treatment and microcapsules addition of endophytic bacteria.

Root Length (cm)

Observations of cocoa root length (*Theobroma cacao* L) showed best result was treatment S3 (14.40 cm) for seed immersion and for microcapsule addtition was B3 treatment (15.78 cm). This research was better than (Wati et al., 2021) used dosage of soil: manure : cocopeat (1:2:1) with root length average 16.65 cm). Based on ability test of bacteria produced auxin (Table 2), endophytic bacteria obtained were able to produce auxin. Auxin produced by endophytic bacteria plays an important role in root growth in cocoa plants. (Jia et al., 2018) reported rate of root growth and expansion of root structure in soil was important for nutrient solubilization and absorption. Auxins played direct role in root growth and development. Auxin production by bacteria has been directly associated with development of host plant's root system and increased root growth and branching. Auxin hormone played a role in process of division, enlargement and expansion of plant cells, especially in root area. Increased root hair growth was certainly influential in increasing area of nutrient absorption for plants (Rosyida & Nugroho, 2017).

Effectiveness of Microcapsules in Cocoa Plants

Microencapsulation was process in which a liquid was wrapped or coated by polymeric material. to produce micro-size, called microcapsules (RiauWati & Chaerunisaa, 2020). Principle of microencapsulation was mixing between water phase, core substance phase and coating material phase until a stable emulsion is formed (Ang et al., 2019). Encapsulation of inoculated cells in polysaccharide polymers such as alginate as a technique to ensure controlled release of beneficial plant microorganisms into soil (Vassilev et al., 2020). Bacteria microencapsulation used alginate has been tested to increase survival by 80-95% (Suryani et al., 2019).

The addition of alginates increases size and appearance of resulting capsules. But interactions between bacterial cells and matrix components may also had an important role especially in release behavior and survival stability of biofertilizer cells (Meftah

Kadmiri et al., 2021). Bacterial encapsulation was an alternative technology intended to protect microbial cells introduced into soil and to ensure their slow and prolonged release, formulations with alginates are more efficient in stability of cell survival which was essential to guarantee a higher number of cells in capsule when applied to plants (Meftah Kadmiri et al., 2021). When released from the capsule the bacteria would colonized the root zone and allowed for more efficient absorption of water and nutrients as it produces growth hormones which enhance root growth. Similarly, the cyanobacterium, when released, will also enable nutrient bioavailability and nitrogen fixation, as well as the production of various growth hormones and bio-stimulants (El Semary et al., 2020).

Microbes derived from cocoa plant (*Theobroma cacao* L.) had potential as a potential biofertilizer that can be used as biofertilizer in a composition (Nurmayulis et al., 2023). Overall, biofertilizers are conducive for cocoa development seedlings in nursery, which guarantees good productivity (Djenatou et al., 2020). Application of biological fertilizer *Azosprilum brasilense* DSM1690 (Ab) packaged in alginate with addition of both types of mineral clay significantly increased plant growth parameters compared to control (Meftah Kadmiri et al., 2021). Research (Gandhi et al., 2021) showed changes in concentration of evective biofertilizers provide highest value for: 10 pods, 42.8 pods, and a yield of 0.71 kg per tree or equivalent to 591.67 kg/ha of dry cocoa beans. Another research demonstrated that in vivo application to lettuce plants of beads containing plant growth-promoting bacterium *Bacillus subtilis* CC-pg104 achieved significant growth promotion by increasing shoot length and roots and ensuring effective root and *Rhizospheric* colonization. Thus, humic acid added to this formulation boosted viability of these cells during storage, ensured progressive cell release, and protected bacteria against unfavorable environmental factors (De Melo et al., 2016).

CONCLUSION

1. Result of isolation from cocoa roots and stems obtained 5 isolates of endophite bacteria. Auxin test showed that 5 isolates were able to produce auxin.
2. Observation of plant height showed that best treatment was S1 treatment (31.84 cm). Observation of total leaves showed that best treatment was S3 treatment (7.92 strands). Observation of stem diameter showed that best treatment was S3 treatment (4.01 mm). Observation of leaf area showed that best treatment was treatment B1 (66.64 cm2). For plant wet weight parameter, the highest data was on S3 treatment (18.41 g) and for root length parameter, highest data was S3 treatment (14.40 cm).
3. Results of this research showed that application of suspension and endophite bacteria microcapsules significantly increased growth of cocoa.

REFERENCES

Ang, L. F., Darwis, Y., Por, L. Y., & Yam, M. F. (2019). Microencapsulation Curcuminoids For Effective Delivery In Pharmaceutical Application. *Pharmaceutics*, *11*(9). https://doi.org/10.3390/Pharmaceutics11090451

Ariana, R. (2016). *Potensi Bakteri Endofit Dalam Meningkatkan Pertumbuhan Tanaman Tembakau Yang Terinfeksi Nematoda Puru Akar (Meloidogyne spp.)*. *4*(1), 1–23.

Arifah, N., Mayani, N., & Hayati, E. (2018). Pengaruh Pemberian Pupuk Hayati Bioboost Terhadap Pertumbuhan dan Hasil Beberapa Varietas Kacang Tanah (Arachis Hypogaea L.). *Jurnal Ilmiah Mahasiswa Pertanian*, *3*(2), 101–108. https://doi.org/10.17969/Jimfp.V3i2.7433

Aulia Meyuliana, Muharama Yora, Nur Salamah Harahap, Yuli Wahyu Eka Putri, Sri Rahmadina, Yelmi Wahyuni, Zulfi Marisa Elfian, Amalia Putri, & Ica Safitri. (2022). Pengaruh Pemberian Beberapa Dosis Pupuk Organik Cair (POC) Terhadap Pertumbuhan Bibit Kakao (*Theobroma Cacao* L.). *Jurnal Riset Perkebunan*, *3*(1), 12–17. https://doi.org/10.25077/Jrp.3.1.12-17.2022

Bashan, Y. (2016). Encapsulated Formulations For Microorganisms In Agriculture and The Environment . *Bioencapsulation Innovations*, *May*, 4–5.

Ben Salah, I., Aghrouss, S., Douira, A., Aissam, S., El Alaoui-Talibi, Z., Filali-Maltouf, A., & El Modafar, C. (2018). Seaweed Polysaccharides As Bio-Elicitors Of Natural Defenses In Olive Trees Against *Verticillium* Wilt of Olive. *Journal Of Plant Interactions*, *13*(1), 248–255. https://doi.org/10.1080/17429145.2018.1471528

De Melo, B. A. G., Motta, F. L., & Santana, M. H. A. (2016). Humic Acids: Structural Properties And Multiple Functionalities For Novel Technological Developments. *Materials Science And Engineering C*, *62*, 967–974. https://doi.org/10.1016/J.Msec.2015.12.001

Dekaindo. (2016). *Dewan Kakao Indonesia (Dekaindo) Laporan Penyelenggaraan Lokakarya " Menyongsong Pemberlakuan Peraturan Menteri Pertanian " Tentang Persyaratan Mutu Dan Pemasaran Biji Kakao*. *3*, 5–8.

Djenatou, P., Patrick Ngoh Dooh, J., Philippe, K., & Léonard Ngonkeu Mangaptche, E. (2020). Evaluation Of The Inoculation Effect Of Arbuscular Mycorrhizal Fungi On The Growth Of Cocoa Seedlings (*Theobroma cacao* L.) In The Nursery. *International Journal Of Sciences*, *9*(07), 6–13. https://doi.org/10.18483/Ijsci.2352

El Semary, N. A. H., Alouane, M. H. H., Nasr, O., Aldayel, M. F., Alhaweti, F. H., & Ahmed, F. (2020). Salinity stress mitigation using encapsulated biofertilizers for sustainable agriculture. *Sustainability (Switzerland)*, *12*(21), 1–16. https://doi.org/10.3390/su12219218

Gandhi, A., Ala, A., & Nasaruddin. (2021). Effectivity of Biofertilizer and Shoot Pruning On Yield of Cocoa (*Theobroma cacao* L). *IOP Conference Series: Earth And Environmental Science*, *807*(4). https://doi.org/10.1088/1755-1315/807/4/042060

Giyanto, G., & Anwar Arifin, F. (2019). *Formulasi Bakteri Endofit Asal Tanaman Kakao (Theobroma cacao* L.*) Sebagai Biopestisida Fauzi Anwar Arifin*. *October*. https://www.researchgate.net/publication/336588446

Herlina, L., Pukan, K. K., & Mustikaningtyas, D. (2016). Kajian Bakteri Endofit Penghasil IAA (Indole Acetic Acid) Untuk Pertumbuhan Tanaman. *J. Fmipa, Universitas Negeri Semarang*, *14*(1), 51–58.

Herlina, L., Pukan, Kr. Kedeti, & Mustikaningtyas, D. (2017). The Endophytic Bacteria Producing IAA (Indole Acetic Acid) In *Arachis hypogaea*. *Cell Biology And*

Development, *1*(1), 31–35. https://doi.org/10.13057/Cellbioldev/V010106

Jamidi, J., Faisal, F., & Fadhil Ichsan, M. (2021). Aplikasi Pupuk Organik Cair Limbah Kulit Nanas dan Pukan Sapi Terhadap Pertumbuhan Bibit Kakao (*Theobroma cacao*, L.). *Jurnal Agrium*, *18*(2), 145–153. https://doi.org/10.29103/Agrium.V18i2.5332

Jia, X., Liu, P., & Lynch, J. P. (2018). Greater Lateral Root Branching Density In Maize Improves Phosphorus Acquisition From Low Phosphorus Soil. *Journal of Experimental Botany*, *69*(20), 4961–14790. https://doi.org/10.1093/Jxb/Ery252

Khaeruni, A., Nirmala, T., Siti Anima Hisein, W., Gusnawaty, G., Wijayanto, T., & Kade Sutariati, G. A. (2020). Potensi Dan Karakterisasi Fisiologis Bakteri Endofit Asal Tanaman Kakao Sehat Sebagai Pemacu Pertumbuhan Benih Kakao. *Jurnal Ilmu Pertanian Indonesia*, *25*(3), 388–395. https://doi.org/10.18343/Jipi.25.3.388

Krisdayani, P. M., Proborini, M. W., & Kriswiyanti, E. (2020). *Pengaruh Kombinasi Pupuk Hayati Endomikoriza , Trichoderma spp ., dan Pupuk Kompos Terhadap Pertumbuhan Bibit Sengon (Paraserianthes falcataria (L .) Nielsen). 8*(3), 400–410.

Maghfoer, M. D. (2018). *Teknik Pemupukan Terung Ramah Lingkungan*.

Marwan, H., Nusifera, S., & Mulyati, S. (2021). Potensi Bakteri Endofit Sebagai Agens Hayati Untuk Mengendalikan Penyakit Blas Pada Tanaman Padi. *Jurnal Ilmu Pertanian Indonesia*, *26*(3), 328–333. https://doi.org/10.18343/Jipi.26.3.328

Meftah Kadmiri, I., El Mernissi, N., Azaroual, S. E., Mekhzoum, M. E. M., Qaiss, A. E. K., & Bouhfid, R. (2021). Bioformulation of Microbial Fertilizer Based On Clay And Alginate Encapsulation. *Current Microbiology*, *78*(1), 86–94. https://doi.org/10.1007/S00284-020-02262-2

Moshinsky, M. (2020). Potensi Kultur Campuran Bakteri Endofit Sebagai Pemacu Pertumbuhan Bibit Tanaman Karet. *Nucl. Phys.*, *13*(1), 104–116.

Nurmayulis, N., Sodiq, A. H., Eris, F. R., Hastuti, D., Denny, Y. R., & Susilowati, D. N. (2023). Molecular Identification of Microbes From The Soil Rhizosphere of Cocoa As A Potential Biofertilizer. *Agrivita Journal Of Agricultural Science*, *45*(1), 124–130. https://doi.org/10.17503/agrivita.V45i1.3840

Panichikkal, J., Prathap, G., Nair, R. A., & Krishnankutty, R. E. (2021). Evaluation Of Plant Probiotic Performance of *Pseudomonas* sp. Encapsulated In Alginate Supplemented With Salicylic Acid And Zinc Oxide Nanoparticles. *International Journal of Biological Macromolecules*, *166*, 138–143. https://doi.org/10.1016/J.Ijbiomac.2020.10.110

Permadi, B. (2021). Pengaruh Pupuk Organik Cair (POC) Urine Kambing Terhadap Pertumbuhan Bibit Kakao (*Theobroma cacao* L.). *Jurnal Mahasiswa Agroteknologi (Jmatek) Bayu Permadi*, *2*(1), 35–40. Https://Jurnal.Ulb.Ac.Id/Index.Php/Jmatek/Article/View/2030

Pradana, A. P., Munif, A., & S, S. (2020). Formulasi Konsorsium Bakteri Endofit Untuk Menekan Infeksi Nematoda Puru Akar *Meloidogyne incognita* Pada Tomat. *Techno: Jurnal Penelitian*, *9*(2), 390. https://doi.org/10.33387/Tjp.V9i2.2210

Prihatiningsih, N., Djatmiko, H. A., & Lestari, P. (2021). Endophytic Bacteria Associated With Rice Roots From Suboptimal Land As Plant Growth Promoters. *Biodiversitas*, *22*(1), 432–437. https://doi.org/10.13057/Biodiv/D220153

Puspita, F., Saputra, S. I., & Merini, D. J. (2019). Uji Beberapa Konsentrasi Bakteri *Bacillus* sp. Endofit Untuk Meningkatkan Pertumbuhan Bibit Kakao (*Theobroma cacao* L.). *Jurnal Agronomi Indonesia (Indonesian Journal Of Agronomy)*, *46*(3), 322–327. https://doi.org/10.24831/Jai.V46i3.16342

Putri, D., Munif, A., & Mutaqin, K. H. (2016). Lama Penyimpanan, Karakterisasi Fisiologi, Dan Viabilitas Bakteri Endofit *Bacillus* sp. Dalam Formula Tepung. *Jurnal Fitopatologi Indonesia*, *12*(1), 19–26. https://doi.org/10.14692/Jfi.12.1.19

Riauwati, R., & Chaerunisaa, A. Y. (2020). Review Teknik Mikroenkapsulasi Pada Ekstrak Mangosteen (A Review of Microencapsulation Techniques In Mangosteen Extract). *Journal Of Current Pharmaceutical Science*, *3*(2), 2598–2095.

Rosyida, R., & Nugroho, A. S. (2017). Pengaruh Dosis Pupuk NPK Majemuk dan PGPR (*Plant Growth Promoting Rhizobacteria*) Terhadap Bobot Basah dan Kadar Klorofil Daun Tanaman Pakcoy (*Brassica rapa* L.). *Bioma : Jurnal Ilmiah Biologi*, *6*(2), 42–56. https://doi.org/10.26877/Bioma.V6i2.1716

Sabahannur, S., Nirwana, N., & Subaedah, S. (2016). Kajian Mutu Biji Kakao Petani Di Kabupaten Luwu Timur, Soppeng dan Bulukumba. *Jurnal Industri Hasil Perkebunan*, *11*(2), 59. https://doi.org/10.33104/Jihp.V11i2.3412

Saberi-Rise, R., & Moradi-Pour, M. (2020). The Effect of *Bacillus subtilis* Vru1 Encapsulated In Alginate–Bentonite Coating Enriched With Titanium Nanoparticles Against *Rhizoctonia solani* On Bean. *International Journal Of Biological Macromolecules*, *152*, 1089–1097. https://doi.org/10.1016/J.Ijbiomac.2019.10.197

Salo, E. N., & Novero, A. (2020). Identification and Characterisation Of Endophytic Bacteria From Coconut (*Cocos nucifera*) Tissue Culture. *Tropical Life Sciences Research*, *31*(1), 57–68. https://doi.org/10.21315/Tlsr2020.31.1.4

Saputri, Y., Advinda, L., Chatri, M., & Handayani, D. (2020). *Potential Bacillus sp. In Producing Indole Acetic Acid (Iaa) And Its Effect On Sprouts Root Length Of Red Chili Seeds (Capsicum annuum L.) Potensi Bacillus sp. Dalam Menghasilkan Indole Acetic Acid (Iaa) Serta Pengaruhnya Terhadap Panjang Akar Kecambah Benih Cabai*. *5*(2), 96–105.

Saridewi, L. P., Prihatiningsih, N., & Djatmiko, H. A. (2020). Karakterisasi Biokimia Bakteri Endofit Akar Terung Sebagai Pemacu Pertumbuhan Tanaman Dan Pengendali Penyakit Layu Bakteri Pada Tanaman. *Jurnal Proteksi Tanaman Tropis*, *1*(1), 1. https://doi.org/10.19184/Jptt.V1i1.15579

Sihombing, IH., Pinem,MI, & Safni, I. (2019). Pengujian Bakteri Endofit Asal Cabai Dalam Menekan Pertumbuhan *F. Oxysporum* f.sp. *capsici* Penyebab Penyakit Layu Fusarium Pada Cabai. *Agroekoteknologi*, *7*(2), 339–346.

Singh, R., Pandey, K. D., Singh, M., Singh, S. K., Hashem, A., Al-Arjani, A. B. F., Abd_Allah, E. F., Singh, P. K., & Kumar, A. (2022). Isolation And Characterization of Endophytes Bacterial Strains Of *Momordica charantia* L. And Their Possible Approach In Stress Management. *Microorganisms*, *10*(2), 0–13. https://doi.org/10.3390/Microorganisms10020290

Sriharti, S., & Dyah, S. (2018). Utilization Of Cacao Waste (*Theobroma cacao* L) For Composting By Using Various Activator Materials. *Aip Conference Proceedings*, *2024*(2018). https://doi.org/10.1063/1.5064337

Suryani, N., Suzanti Betha, O., Fakultas, M., Kesehatan, I., Syarif, U., & Jakarta, H. (2019). Uji Viabilitas Mikroenkapsulasi *Lactobacillus casei* Menggunakan Matrik Natrium Alginat Microenkapsulation Viability Test of *Lactobacillus casei* Using Sodium Alginate Matric. *Jurnal Farmasi Lampung*, *8*(1), 1–8. https://digilib.utb.ac.id/Index.Php/Jfl/Article/Download/80/75

Usrin, U., Pamungkas, D. H., & Widata, S. (2019). Respon Pertumbuhan Bibit Kakao (*Theobroma cacao* L.) Terhadap Pemberian Pupuk Kandang Kambing Dan Pupuk Organik Cair (POC). *Respon Pertumbuhan Bibit Kakao (Theobroma cacao L.) Terhadap Pemberian Pupuk Kandang Kambing Dan Pupuk Organik Cair (Poc)*, *July*, 65–83.

Vassilev, N., Vassileva, M., Martos, V., Garcia Del Moral, L. F., Kowalska, J., Tylkowski, B., & Malusá, E. (2020). Formulation Of Microbial Inoculants By Encapsulation In Natural Polysaccharides: Focus On Beneficial Properties Of Carrier Additives And Derivatives. *Frontiers In Plant Science*, *11*(March), 1–9. https://doi.org/10.3389/Fpls.2020.00270

Walida, H., Harahap, F. S., Hasibuan, M., & Yanti, F. F. (2019). Isolasi Dan Identifikasi Bakteri Penghasil IAA dan Pelarut Fosfat Dari Rhizosfer Tanaman Kelapa Sawit. *Biolink (Jurnal Biologi Lingkungan Industri Kesehatan)*, *6*(1), 1. https://doi.org/10.31289/Biolink.V6i1.2090

Warsito, K., Alfarizky, M. D., & Ardiansyah, A. (2022). The Influence Of Liquid Organic Fertilizer Coconut Water And Chicken Manure On Cocoa (*Theobroma Cacao* L.) Plant Growth. *International Conference Of Science Technology And Social Humanities*, 31–37.

Wati, L., Nurhayati, N., & Hasanuddin, H. (2021). Pengaruh Media Tanam Dan Konsentrasi Pupuk Organik Cair Terhadap Pertumbuhan Bibit Kakao (*Theobroma cacao* L.). *Jurnal Ilmiah Mahasiswa Pertanian*, *6*(4), 801–808. https://doi.org/10.17969/Jimfp.V6i4.18254

Wu, Z., Li, X., Liu, X., Dong, J., Fan, D., Xu, X., & He, Y. (2019). Membrane Shell Permeability Of Rs-198 Microcapsules and Their Ability For Growth Promoting Bioactivity Compound Releasing. *Rsc Advances*, *10*(2), 1159–1171. https://doi.org/10.1039/C9ra06935f

Yusuf, H., Sahputra, R., & Sah, R. I. (2018). Pengaruh Media Tanam Dan Pemberian Pupuk Organik Cair Terhadap Pertumbuhan Bibit Kakao (*Theobroma cacao*, L). *Jurnal Penelitian …*, *5*(1), 1–11. https://jurnal.unsam.ac.id/Index.Php/Jagrs/Article/View/850

Zabot, G. L., Schaefer Rodrigues, F., Polano Ody, L., Vinícius Tres, M., Herrera, E., Palacin, H., Córdova-Ramos, J. S., Best, I., & Olivera-Montenegro, L. (2022). Encapsulation of Bioactive Compounds For Food And Agricultural Applications. *Polymers*, *14*(19). https://doi.org/10.3390/polym14194194

Zain, N. M., Bachtiar, T., & Sugoro, I. (2018). Kontribusi Nitrogen Dari Bakteri Endofit Pada Tanaman Padi. *Jurnal Ilmiah Aplikasi Isotop Dan Radiasi*, *14*(1), 1. https://doi.org/10.17146/Jair.2018.14.1.4152

How To Cite This Article, with *APA style* :
Prayoga G. Y., Warsito K., & Mutia Z.N.A.H. (2023). Invasion of Endophytic Bacteria by Using Microencapsulation Technology as Stimulant in Cocoa Plants (*Theobroma cacao* L.) *Jurnal Pembelajaran dan Biologi Nukleus*, *9*(2), 201-218. https://doi.org/10.36987/jpbn.v9i2.3908