

Research Horizon

Vol. 2, no. 1, (2022), 302-312

Website: <http://journal.publindoakademika.com/index.php/RH>

Growth Rate of *Rhizophora Mucronata* Seedlings in Coastal Areas of Central Java

Eva Widayanti^{1, *}, Teguh Firmansyah²

¹ *Diponegoro University,
Semarang, Indonesia*

* Corresponding author:
evayanti.undip@gmail.com

Received : Nov 13, 2021

Revised : Jan 17, 2022

Accepted : Feb 2, 2022

Abstract

Rhizophora mucronata is a type of mangrove from the *Rhizophora* family that can have high adaptability to an environment. The seed nursery process can be carried out by several methods, including the wetland and dry land methods. This study aims to determine the growth of mangroves. The material used in this fieldwork practice is to see how the techniques and methods of mangrove nurseries (*Rhizophora mucronata*) are used by the NGO Biota Foundation. The methods include preparing maintenance by embedding propagules in polybags using the wetland method in tidal areas. The results show the growth of *Rhizophora mucronata* mangrove from the pericarps root size, reaching 0.1 mm at four weeks.

Keywords

Rhizophora mucronata, mangrove growth, wetland method, dry land method.

1. Introduction

Indonesia has mangrove forests grow and spread throughout the archipelago, from Sumatra Island to Papua Island. Mangroves are typical coastal plant formations along protected tropical and sub-tropical beaches. The mangrove ecosystem is a community of plants that adapt to salinity and tides of seawater. This ecosystem has an important role and great benefits for people's lives, especially around the coast.

A study of global mangrove area estimation conducted by FAO (2007) showed that Indonesia had 3,062,300 hectares of mangrove forest in 2005, which is 19% of the total area of mangrove

forests worldwide (Haryani, 2013). According to Mulyadi et al. (2014), there are 60 species of mangrove plants in Indonesia, while around the world, there are around 75 species of mangroves. Of these species, as many as 43 are valid mangrove plant species, while the other species are plant species usually associated with mangrove forests. Of the 43 mangrove species, 33 species are classified as trees, and the rest are shrubs.

Although the State of Indonesia has the largest mangrove forest, the rate of deforestation and mangrove forest degradation is also occurring, which is a problem with the destruction of mangrove forests. The destruction of mangrove forests for aquaculture or due to uncontrolled logging has a negative impact on the marine environment in the form of sedimentation, which in turn destroys coral reefs and seagrass beds. Sedimentation also increases turbidity, which causes a decrease in environmental feasibility for tourism and fisheries.

Mangrove ecosystems have functions such as protecting the coast from waves, currents, and wind; shelter, spawn or breed, and nursery areas for various types of biota; producer of highly productive organic matter (detritus); source of raw material for the fuel industry; suppliers of fish, shrimp, and other marine biota larvae; as well as tourist sites (Bengen, 2000; Indrayanti et al., 2015). Protecting mangrove forests is important, considering that mangroves have broad benefits in terms of physical, chemical, biological, and socio-economic aspects. Its physical function is as a windbreak, pollutant filter, wave barrier, flood control, and prevention of seawater intrusion into the mainland. The biological functions are a spawning ground, a nursery ground, and a feeding ground for fish and other marine biotas. Its economic function is as a producer of wood for raw materials and building materials, foodstuffs, and medicines. In addition, this function is strategic as a primary producer capable of supporting and stabilizing marine and land ecosystems (Setiyowati, 2017).

One of the efforts to restore the function of the mangrove ecosystem is through rehabilitation activities which include reforestation of the beach by planting suitable mangroves as has been done independently by the community and supported by related agencies in Mangunharjo Village, Tugu District, Semarang City. Success in mangrove rehabilitation activities is influenced by the availability of quality and timely seeds when needed. To get quality seeds, nursery activities are needed, while to get seeds on time at the required time, it is necessary to analyze the growth of seedlings during the nursery. This study aimed to determine the growth rate of *Rhizophora mucronata* mangrove seedlings in the Biota Foundation area, Mangunharjo Village, Tugu District, Semarang City.

2. Literature Review

2.1 Mangrove

Mangroves are typical coastal plants along tropical and sub-tropical beaches that are protected and influenced by tides and can adapt to brackish waters (RSNI, 2011). Mangroves are plant stands consisting of several families with structural adaptations and the same physiological characteristics in the same habitat, usually located in coastal areas of the tropics and subtropics, which are the most productive ecosystems. Mangroves are a very distinctive coastal ecosystem, with relatively small waves (often protected by waves), influenced by tides and freshwater input

from land areas, while mangrove typology is a study of the types of mangrove vegetation that make up the mangrove ecosystem.

Mangroves are plants whose habitat is mostly in water areas, coastal ecosystems, and swamps. Mangrove vegetation is a group of plants originating from the *Rhizophora* clan. This plant is considered a unique plant because it has very distinctive roots, and its habitat is mostly in coastal ecosystems. Hadi & Irawati (2016) explains that Mangroves or mangroves are the name of a group of plants from the *Rhizophora* clan, *Rhizophoraceae* tribe, with striking characteristics in the form of large and woody *tunjang* roots, shoots covered with tapered supporting leaves, and fruit, which germinate and take root while still on the tree (viviparous).

Mangrove plants have different abilities in adapting to biotic factors (competition and herbivores) and abiotic environmental factors, so the distribution of each species is not always the same. Mangrove plants choose habitats in coastal areas to win the competition with land plants in general, in addition to avoiding herbivores from pests and diseases that usually attack land plants. Basically, mangrove plants can live in fresh waters far from the coast.

2.2 Types of Mangroves

Mangroves are a distinctive set of various types of plants belonging to different tribes but have similarities in adaptation to habitats that are influenced by tides. Each type of mangrove plant has a different degree of availability and abundance in different places and habitat conditions. Mangrove forest ecosystems in Indonesia have the highest biodiversity in the world with a total of 89 species, consisting of 35 plant species, 9 shrub species, 9 liana species, 29 epiphytic species and 2 parasitic species (Mangkay et al., 2012).

Watson (1928) classified mangrove species into two groups. The main group consists of species from the *Rhizophoraceae* tribe and the genera *Sonneratia*, *Avicennia*, and *Xylocarpus*. Additional groups include *Excoecaria agallocha*, *Aegiceras* spp., *Scyphophora hydrophyllacea*, *Lumnitzera* spp., *Oncosperma tigillaria*, *Cerbera manghas*, and others. *Nypa fruticans* is a type of palm plant that can develop and form its community. This species is also part of the additional group of mangrove communities.

According to Sukardjo (1984), based on the composition of flora, structure and general appearance of the forest, several types of mangroves in Indonesia can be identified and briefly described as follows:

1. Bush community

This community is formed by pioneer species found on the edges of the sea or new deltas that are soft and muddy. The flora is dominated by *Avicennia marina*, *A. alba*, and *Sonneratia caseolaris*. *Ceriops tagal* seedlings are also able to grow in this community but are found in transitional areas of low and high tide, for example, in Kuala Sekampung, Lampung, and Karawang, West Java. In this type of mangrove community, the colonization of *Sonneratia* spp. generally occurs near river mouths or the inland of large rivers at the boundary of high tidal influence, where the soil is fine silt, for example, in the Kandilo River, East Kalimantan. Sometimes this community tip is mixed with several types of non-mangrove plants, such as *Phragmites karka*, *Pandanus* spp., *Glochidion littorale*. Cases like this can be found in community areas bordering land or swamp land, where due to the influence of human activities, the mangrove habitat has

changed to become more land-based. The growth in this community is very dense; the trees have short branches and many shoots and form thick, short clumps.

2. Young mangrove community

This community has a single layer of forest canopy that is uniform in height and is composed mainly of *Rhizophora* spp. In a place protected from strong waves, *Rhizophora* spp. also acts as a type of pioneer. These species will also develop after the colonization of *Avicennia* and *Sonneratia* species in habitats that are not good for *Rhizophora* growth. Some species, such as *Avicennia alba*, can survive and can grow to reach heights beyond the *Rhizophora* canopy. At a further level of development, in the young mangrove community, there was a mix of *Rhizophora* species and several other mangrove species such as *Bruguiera*, *Xylocarpus*, and in parts far from the seafront mixed with *Excoecaria agallocha*. This type of mangrove community already has several tall trees, but like a pioneer mangrove forest, the forest canopy is still tight and continuous, so because of the shade on the forest floor, there is very little undergrowth. In the old mangrove forest, trees with a diameter greater than 10 cm are abundant and spread evenly throughout the forest area. More established mangrove forests have a partially open canopy due to natural clumps. With these gaps, light can enter the forest floor so that understory plants, such as *Acrostichum aureum* (sea ferns) and *Acanthus ilicifolius* (*jeruju*), can be found.

3. Old mangrove community

Mangrove communities that have reached their peak of development or are often called climax communities, are often dominated by *Rhizophora* and *Bruguiera* species whose trees are large and tall. *Rhizophora mucronata* and *R. apiculata* dominated the soft mud habitat, *R. stylosa* the sand habitat and *Bruguiera* spp. solid mud. In the climax, community equilibrium has been reached, but it is not stable; dynamics exist, and the changes that occur are internal, while changes in species composition only occur in gaps. Overall, the species composition is relatively constant. The mangrove trees that make up this community type can reach a diameter of 50 cm underneath the gaps, several types of undergrowth also grow, such as *acrostichum aureum*, *derris* spp, and *Acanthus* spp. In mature mangrove forests, it is known that there is a diversity of species, and the composition of the flora is more diverse. Several groups of "marginal" species are often found, especially in places far from the sea or in areas bordering freshwater swamp forests, peat swamp forests, or land forests.

4. Nipah community

In this community, nipa palm trees grow abundantly and are the main species, and often nipa palms develop into large pure communities. In the Nipah community, several types of mangrove trees grow unevenly, such as *Lumnitzera* spp., *Excoecaria agallocha*, *Heritiera littoralis*, *Intsia bijuga*, *Kandelia candel*, and *Cerbera manghas*.

2.3 Mangrove Ecosystem

The mangrove ecosystem is a system of biotic and abiotic environmental interactions in a mangrove habitat. Mangrove ecosystems are complex and changeable, but not stable. It is said to be complex because the ecosystem is filled with mangrove vegetation and is a habitat for animals

and various aquatic biota. The underlying soil is a young saline soil with high clay content, high alkaline saturation value and high cation exchange capacity. The content of organic matter, total nitrogen and ammonium is moderate offshore and high on land. In addition, mangrove ecosystems are highly productive, provide abundant food for a variety of marine animals, and provide breeding, spawning and breeding grounds for a variety of fish, shellfish, crabs and shrimp. Indirectly, human life depends on the existence of mangrove ecosystems in coastal areas (Kariada et al., 2014).

Mangrove forest areas are water areas that have productive ecosystems and are transitional areas between terrestrial and marine environments. Mangrove forests have unique characteristics compared to other forest formations. The uniqueness of the forest can be seen from the habitat in which it lives, as well as the diversity of flora, namely: *Avicennia*, *Rhizophora*, *Bruguiera*, and other plants that can survive the copying of seawater, and fauna, namely crabs, fish, types of mollusks, and others. This area is generally overgrown by typical types of vegetation in the form of plants that are relatively tolerant of changes in salinity due to the influence of tides. Mangrove forests function as coastal protectors that can reduce and prevent erosion of coastal areas. This forest also plays a role in supporting the life of fauna in coastal areas and oceans. Mangroves are a habitat for various types of animals such as primates, reptiles, and birds (Irmawan et al., 2014).

2.4 Mangrove Ecosystem Function

Mangroves also have economic, ecological and social functions. The economic function of mangroves is to produce seeds for household needs, industrial needs and seeds. Its ecological function is to protect the coastline, prevent seawater intrusion, and become the habitat of various birds, etc (Kustanti, 2011). Mangroves have several functions in terms of physical, chemical, biological, and socio-economic aspects. Its physical function is as a windbreak, pollutant filter, wave barrier, flood control, and prevention of seawater intrusion into the mainland. The biological functions are a spawning ground, a nursery ground, and a feeding ground for fish and another marine biota. Its economic function is as a producer of wood for raw materials and building materials, foodstuffs, and medicines. In addition, this function is strategic as a primary producer capable of supporting and stabilizing marine and land ecosystems (Setiyowati, 2017).

Like other forest ecosystems, the mangrove ecosystem has a role as an absorber (sink) of carbon dioxide (CO₂) from the air. According to the International Panel on Climate Change/IPCC (2003), until the end of 2000, carbon emissions in the world were 117±35 G ton C (82-152 G ton C) due to burning fossil fuels in the form of oil and coal, forest conversion and forest burning. To overcome this problem, the role of the forest as a CO absorber must be increased through a mangrove forest management system that is synergistic with the social functions and economic value of the forest (Heriyanto et al., 2016).

Mangroves that live on the coast are very beneficial for the preservation of the environment and resources. A very important function of mangroves is as a liaison between land and sea, plants, animals, and other objects on land and in the sea; the shift will be supported by mangrove forests around the coast and mangrove forests which also naturally function as buffers on waves coming from the sea, the wind blows, and seawater seepage into the land (Wiharyanto et al., 2010).

2.5 Factors Affecting Mangrove Growth

Winata & Yuliana (2014) stated that mangrove forest plant types react differently to variations in the physical environment in their habitat, giving rise to certain vegetation zones. Some of the physical environmental factors are:

1. Substrate type

As a sedimentary area, the substrate on the beach can be very different. The most common are mangroves that grow in clay silt mixed with organic matter. But in some places, the proportion of this organic matter is so great, there are even mangroves growing on peat soil. Another substrate is silt with high sand even dominated by coral debris on beaches close to coral reefs.

2. Waves

The outer or frontal part of the mangrove forest facing the open sea is often subject to strong waves and strong water currents, unlike the quieter inside. A somewhat similar part is the forest that is directly opposite the river's flow, that is, which is located on the bank of the river. The difference is that the salinity on the banks of the river is not so high, especially in parts that are a bit far from the estuary.

3. Inundation by high tide

The outer part of the mangrove forest also experiences the longest and deepest tidal inundation compared to the rest, sometimes even continuously submerged. Meanwhile, parts of the interior of the mangrove forest may only be submerged by seawater once or twice a month when the tide is highest.

The growth of each mangrove diameter is influenced by factors that influence growth, including the substrate. The substrate referred to here is a substrate containing soft mud. *R. mucronata* can live in a place that does not contain mud because the growth of mangroves is affected by the dissolved oxygen content in the mud and the optimal thickness of the mud for the growth of *R. mucronata* is 30 cm.

Budiman et al. (2015) added that the growth of tree diameter is influenced by environmental factors, where environmental factors are influenced by the potential of the soil for plant growth. Soil potential is seen from two aspects, namely the physical condition of the soil and the chemical aspect of the soil. The factors that affect the size of the increment of a stand are silvicultural measures, and the silvicultural action referred to here is stand thinning (Kesuma et al., 2016).

3. Methods

The method used in this study is a descriptive method, which is a method intended to collect information about the actual (real) situation at the time the research was conducted.

3.1 Seed selection

Seed selection is carried out on previously identified seed sources. The selection of seeds must be selected from parent trees that have a good phenotype. The selected seeds are those that already have a ring on the propagule fruit. The seeds used are ripe seeds that have rings about 2-3 cm.

3.2 Nursery

The seeds that have been selected on the mother tree are then sown or sown in the nursery. The people of Mangunharjo Village, especially members of the Biota Foundation Group, use land nurseries where these nursery activities produce seedlings that are resistant to all conditions. The ten seeds that have been collected are then put into polybags with a size of 11 x 17 cm with a thickness of 0.03 cm. After that, the seeds are put into beds with the size of every ten seeds tied together.

3.3 Seedling Growth Rate Analysis

The seeds that have been sown are then analyzed for growth every three days by observing the growth of the seedlings and the surrounding environmental parameters, including temperature, salinity, and pH.

4. Results

This study observed the mangrove seedlings of *Rhizophora mucronata* in the nursery area. The nursery area is an artificial mangrove forest area that is far from the original mangrove forest and is behind densely populated residential areas. This mangrove forest is made with a silvofishery system or surrounds a pond to prevent tidal flooding, which causes some of the residents' settlements to be submerged. The nursery is carried out between the embankment and the mangrove forest that surrounds the pond.

The nursery that is made is a nursery in water, where the seeds can grow faster than the nursery on land; this is because they are exposed to continuous ups and downs. The fruit used is the fruit that is really physiologically ripe. Ripe *R. mucronata* fruit or seeds are characterized by dark green propagules, at least 50 cm long, yellow cotyledons, have white rings on the hypocotyl adjacent to the pericarp, and the pericarp is easily separated from the plumule. It is in accordance with the statement of Rusdiana et al. (2015). When taking propagule from the tree, the level of maturity varies. It will affect the percentage of the life of the propagule itself. If it is getting older or the colour is getting yellower, the growth will be faster.

Table 1. *Rhizophora mucronata* Propagule Length Table

Sample Propagules	Sampling Date					
	12 July	15 July	16 July	20 July	23 July	26 July
A1	41 cm	41 cm	41 cm	41 cm	41 cm	41 cm
A2	43 cm	43 cm	43 cm	43 cm	43 cm	43 cm
A3	46 cm	46 cm	46 cm	46 cm	46 cm	46 cm
A4	33 cm	33 cm	33 cm	33 cm	33 cm	33 cm
A5	41 cm	41 cm	41 cm	41 cm	41 cm	41 cm
A6	43 cm	43 cm	43 cm	43 cm	43 cm	43 cm
A7	40 cm	40 cm	40 cm	40 cm	40 cm	40 cm
A8	45 cm	45 cm	45 cm	45 cm	45 cm	45 cm
A9	33 cm	33 cm	33 cm	33 cm	33 cm	33 cm
A10	35 cm	35 cm	35 cm	35 cm	35 cm	35 cm

Table 2. *Rhizophora mucronata* Propagule Ring Length Table

Sample Propagules	Sampling Date					
	12 July	15 July	16 July	20 July	23 July	26 July
1	3 cm	3 cm	-	-	-	-
2	3 cm	3 cm	-	-	-	-
3	1,5 cm	1,5 cm	-	-	-	-
4	-	-	-	-	-	-
5	3 cm	3 cm	3 cm	-	-	-
6	3 cm	3 cm	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-

The average time the propagules released from the fruit pericarp was on day 9, but on day 3 there were several propagules that had been released. The length of time the propagule pericarp is released is due to the location of the nursery being slightly blocked by lush mangrove trees so that the place becomes cool. On the 6th day, the hypocotyl wilts and began to shrink due to reduced water content. This also affects the pericarp of the fruit, slowly detaching from its propagules and physical damage to the propagules in the form of streaks. After the pieces of fruit were released from the propagules, it was seen that the propagules began to stand back up even though they were not as straight as they used to be.

Table 3. *Rhizophora mucronata* Pericarp Propagule Length Table

Sample Propagules	Sampling Date					
	12 July	15 July	16 July	20 July	23 July	26 July
1	-	-	3 cm	3 cm	3 cm	leaves appear
2	-	-	2,5 cm	2,6 cm	2,6 cm	2,6 cm
3	-	-	3,5 cm	3,6 cm	3,6 cm	leaves appear
4	2,5 cm	2,5 cm	2,7 cm	2,8 cm	2,8 cm	leaves appear
5	-	-	-	2,9 cm	2,9 cm	leaves appear
6	-	-	2,8 cm	3 cm	3 cm	3 cm
7	3 cm	3 cm	3 cm	3 cm	3 cm	3 cm
8	2 cm	2 cm	2,1 cm	2 cm	2 cm	2 cm
9	2 cm	2 cm	2 cm	2 cm	2 cm	2 cm
10	2,2 cm	2,2 cm	2,2 cm	2,2 cm	2,2 cm	2,2 cm

The process of bud growth from this study began to be seen on day 18, but only 4 propagules had leaves. In accordance with Kamil's (1982) statement in Rusdiana (2015) who stated that visually and morphologically, a germinating seed is generally characterized by visible leaves that protrude from the seeds. The time for *R. mucronata* propagules to bud off (germination) was 8 weeks after planting, the second leaf time was 11 weeks after planting, and the 4 leaf time was 14 weeks after planting. Several factors affect its growth, including the maturity of the seeds, size, ripe or not, the origin of the seeds and water penetration, and other elements in the seed coat.

Table 5. Table of Root Diameter Propagules Mangrove *Rhizophora mucronata*

Sample Propagules	Sampling Date					
	12 July	15 July	16 July	20 July	23 July	26 July
1	1,5 cm	1,5 cm	1,5 cm	1,5 cm	1,5 cm	1,5 cm
2	1,5 cm	1,5 cm	1,5 cm	1,5 cm	1,5 cm	1,5 cm
3	1,72 cm	1,72 cm	1,72 cm	1,72 cm	1,72 cm	1,72 cm
4	1,5 cm	1,5 cm	1,5 cm	1,5 cm	1,5 cm	1,5 cm
5	1,745 cm	1,745 cm	1,745 cm	1,745 cm	1,745 cm	1,745 cm
6	1,16 cm	1,16 cm	1,16 cm	1,16 cm	1,16 cm	1,16 cm
7	0,955 cm	0,955 cm	0,955 cm	0,955 cm	0,955 cm	0,955 cm
8	1,25 cm	1,25 cm	1,25 cm	1,25 cm	1,25 cm	1,25 cm
9	1,175 cm	1,175 cm	1,175 cm	1,175 cm	1,175 cm	1,175 cm
10	1,15 cm	1,15 cm	1,15 cm	1,15 cm	1,15 cm	1,15 cm

Root growth in propagules is influenced by inundation and water depth. Growth in the root system of *Rhizophora* spp. in mangrove areas with high inundation conditions will indicate the position of the roots that are far below the soil surface; on the contrary if the inundation is getting shallower, then the position of the roots will be close to the soil surface (Triswanto 2000). In this study, the roots appear after the presence of yellow nodules at the end of the mangrove, which will later grow into roots. Yellow nodules begin to appear on day 12; then roots appear on day 25.

Table 6. Environmental Parameter Data

Sampling Date	12 July	15 July	16 July	20 July	23 July	26 July
Salinity	35 ppt	35 ppt	33 ppt	32 ppt	32 ppt	34 ppt
Temperature	25 ⁰ C	28 ⁰ C	28 ⁰ C	26 ⁰ C	27 ⁰ C	26 ⁰ C
pH	8	8	8	8	8	8

At the time of the study, it was known that the average salinity of the nursery environment was 33 ppt, with an average temperature of 250 C and an average pH of 8, where this salinity result exceeded the quality standard, which stated that mangrove *Rhizophora mucronata* could live at a salinity of 10 -30 ppt, temperature 23-320 C, and pH between 7-8.5 (Kusmana et al., 2003). However, mangrove seedlings can still grow even though their growth is slow. It is because the *R. mucronata* mangrove can adapt well to its environment. In addition, the absence of predators entering the nursery area supports mangrove seedlings in growing.

5. Conclusion

Based on the research, it is known that the growth of mangrove seedlings will occur when the propagules have appeared roots marked by the appearance of yellow nodules on the propagules on the 25th day. The buds that will become leaves begin to appear on the 18th day. *Rhizophora mucronata* can adapt to conditions in the environment in which the plant grows. However, in general, *Rhizophora mucronata* can live at a salinity of 10 – 30 ppt, a temperature of 230 – 320 C, and a pH of 7 – 8.5.

References

- Budiman, M., Hardiansyah, G., & Darwati, H. (2015). Estimasi Biomassa Karbon Serasah Dan Tanahpada Basal Area Tegakan Meranti Merah (*Shorea Macrophylla*) Di Areal Arboretumuniversitas Tanjungpura Pontianak. *Jurnal Hutan Lestari*, 3(1).
- Hadi, A. M., & Irawati, M. H. (2016). Pemanfaatan Tanaman Mangrove di Kawasan Pancer Pantai Cengkong Trenggalek Jawa Timur sebagai Media Belajar Biologi Siswa SMA.
- Haryani, H. (2016). Model Mitigasi Bencana di Wilayah Pesisir dengan Pemberdayaan Masyarakat. *TATALOKA*, 14(3), 201-212.
- Heriyanto, N. M., & Subiandono, E. (2016). Peran biomassa mangrove dalam menyimpan karbon di Kubu Raya, Kalimantan Barat. *Jurnal Analisis Kebijakan*, 13(1), 1-12.
- Indrayanti, M. D., Fahrudin, A., & Setiobudiandi, I. (2015). Penilaian Jasa Ekosistem Mangrove di Teluk Blanakan Kabupaten Subang. *Jurnal Ilmu Pertanian Indonesia*, 20(2), 91-96.
- Irmawan, A., Nurdjali, B., & Siahaan, S. (2014). Identifikasi Jenis-Jenis Burung Air Di Kawasan Mangrove Desa Tanjung Saleh Kecamatan Kakap Kabupaten Kubu Raya. *Jurnal Hutan Lestari*, 2(3).
- Kariada, N. T., & Irsadi, A. (2014). Peranan mangrove sebagai biofilter pencemaran air wilayah tambak bandeng Tapak, Semarang (Role of mangrove as water pollution biofilter in milkfish pond, Tapak, Semarang). *Jurnal manusia dan lingkungan*, 21(2), 188-194.
- Kesuma, R. A., Kustanti, A., & Hilmanto, R. (2016). Pertumbuhan riap diameter pohon bakau kurap (*Rhizophora mucronata*) di Lampung Mangrove Center. *Jurnal Sylva Lestari*, 4(3), 97-106.

- Kusmana, C., Wilarso, S., Hilwan, I., Pamoengkas, P., Wibowo, C., Tiryana, T., ... & Yunasfi, H. (2003). Teknik rehabilitasi mangrove. *Fakultas Kehutanan IPB. Bogor*, 177.
- Kustanti, A. (2011). *Manajemen hutan mangrove*. PT Penerbit IPB Press.
- Mangkay, S., Harahap, N., Polii, B., & Soemarno, S. (2012). Analisis Strategi Pengelolaan Hutan Mangrove Berkelanjutan Di Kecamatan Tatapaan, Minahasa Selatan, Indonesia. *Indonesian Journal of Environment and Sustainable Development*, 3(1).
- Mulyadi, E., & Fitriani, N. (2010). Konservasi hutan mangrove sebagai ekowisata. *Jurnal Ilmiah Teknik Lingkungan*, 2(1), 11-18.
- Rancangan Standart Nasional Indonesia. 2011. Survey dan pemetaan mangrove. RSNI: 2011.
- Rusdiana, O., Sukendro, A., & Baiquni, A. R. (2015). Pertumbuhan bakau merah (*rhizophora mucronata*) di Persemaian Mangrove Desa Muara, Kecamatan Teluk Naga, Kabupaten Tangerang. *Jurnal Silvikultur Tropika*, 6(3), 172-178.
- Setiyowati, D., Supriharyono, S., & Triarso, I. (2017). Valuasi ekonomi sumberdaya mangrove di Kelurahan Mangunharjo, Kecamatan Tugu, Kota Semarang Economic Valuation of Mangrove Resources in the Mangunharjo Village Tugu Sub District, Semarang City. *SAINTEK PERIKANAN: Indonesian Journal of Fisheries Science and Technology*, 12(1), 67-74.
- Setyorini, H. B. (2013). Budayakemiskinan nelayan di mangunharjo semarang. *Sabda: Jurnal Kajian Kebudayaan*, 8(1), 7-17.
- Sukardjo, S. (1984). Ekosistem mangrove. *Jurnal Oseana*, 9.
- Triswanto, A. (2000). Pengaruh Kedalaman Air Pasang dan Umur Tanaman terhadap Keberhasilan Penanaman *Rhizophora mucronata* Lamk. (Studi Kasus Rehabilitasi Pulau-Pulau Kecil di Gili Petagan, Nusa Tenggara Barat).
- Watson, J. G. (1928). Mangrove forests of the Malay Peninsula. *Malayan forest records*, 6.
- Wiharyanto, D., & Laga, A. (2010). Kajian pengelolaan hutan mangrove di kawasan konservasi Desa Mamburungan Kota Tarakan Kalimantan Timur. *Media Sains*, 2(1), 10-17.
- Winata, A., & Yuliana, E. (2016). Tingkat keberhasilan penanaman pohon mangrove (kasus: pesisir Pulau Untung Jawa Kepulauan Seribu). *Jurnal Matematika Sains dan Teknologi*, 17(1), 29-39.