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The Effect of NAA and Ga3on The Growth Performance of *Ceriops tagal* Seedling

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Abstract

Plant Growth Regulator (PGR) had been widely utilized in improving plant quality and productivity. The mechanism includes the manipulation of plant adaptibility over environmental stress. This research aimed to study the efect of PGR on the growth of *C. tagal* seedling and to formulate the applicable treatment to improve its growth performance. The research was conducted through laboratory experiment, including tthe combination of NAA and GA_3 with the designed concentration of 0 ppm, 150 ppm and 300 ppm. The experiment lasted for one month and involved weekly observation. The plants were treated by spraying once every three days. Observations were conducted to the survival rate, height increment and leaf number development. ANOVA was conducted as statistical analysis method. The result showed that there were no significant effect of PGRs on the height increment of *C. tagal* seedling. The survival rate was lowest in the control and 150 ppm NAA treatments, while treatment with 300 ppm $GA_3$was highest. The application of 300 ppm $GA_3$was the best treatment for the livelihood of *C. tagal* seedling, while the application of 150 ppm GA_3 was considerable alternative due to its growth performance. This research provide a novel finding concerning the application of PGRs on the seeding process of C. tagal. Thus, it could be applied in the seeding activities by the mangrove farmers to improve the productivity and quality of mangrove seedling.

How to Cite

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INTRODUCTION

The improvement of mangrove seedling quality is required in order to enhance its adaptation capability. Increasing upland and coastal area development had caused the severe damage of the ecosystem (Shahbudin, *et al.*, 2012). Thus, mangrove could not establish and grow optimally. Plantation efforts had been conducted to hinder further coastal degradation and to initiate the ecosystem recovery(Andradi-Brown, *et al.*, 2013). Even though, the diversity of mangrove which had been decreased needs to be restored as well.

Rehabilitation of mangrove ecosystem is generally conducted through plantation of pioneer species such as Avicennia marina and Rhizophora mucronata (Munandar, *et al.*, 2014). The utilization of any other species usually resulted in low survival and growth rate. Unsuitable environmental condition had been considered as the main affecting factor (Sofawi, *et al.*, 2017). Coastal degradation lead to the change of erosion-sedimentation pattern, soil structure, tidal area, inundation periods and etc (Lageweg & Slangen, 2017). Thus, the environmental condition can no longer support the establishment of several mangrove species, while the existing plants might get disturbed as well.

The development of mangrove ecosystem including the species enrichment occurs through the succession which requires a very long period. Thus, the environmental sutiability for the establishment of particular mangrove species might be achieved after decades (Cunha-Lignon *et al.*, 2009) and; T4. The consequences would be the low mangrove diversity in the degraded coastal area, or worse, it may only consisted of single mangrove species due to environmental limitation.

In order to overcome this problem, several efforts could be conducted to improve the adaptability of particular mangrove species to the existing environmental condition. These efforts could be the modification of plantation technique (Andradi-Brown *et al.*, 2013), site (Bashan, *et al.*, 2013) a hurricane moved a large sand dune, blocking the sole outlet channel of a mangrove. In the absence of daily tidal flow, the two ponds containing the mangrove vegetation evaporated, the secondary drainage channels were lost, and a salt crust formed on the bed of the ponds. The mangrove lost most of its trees and the remaining suffered from osmotic shock that led to defoliation. Restoration involved creating a knickpoint retreat (waterfall retreat effect, or improvement of seedling quality (Cortina, *et al.*, 2013). The first and second are generally applied in the field application. Furthermore, the application of the third method is not common to the farmers.

Plant growth regulators (PGR) are the important components of plant which define the growth pattern. The substances play the role in stimulating or inhibiting the development of particular plant organs (Giron, *et al.*, 2013). The application of PGR includes the genetical modification of plants for certain purposes, such as increasing growth and crop production (Sari, *et al.*, 2014), shorten the productive age, improving the adaptability (Saputro, *et al.*, 2016), etc. In the last few decades, genetical engineering had been taking the responsibility on the development of new plant varieties (Ren, *et al.*, 2011).

Naphtalene Acetic Acid (NAA) and Gibberellic Acid (GA_3) are some of the generally utilized PGR for plant genetic modifications. The NAA belongs to the auxin group compounds which has the function in stimulating callus and organ (Zayova, *et al.*, 2012). The NAA is frequently used to increase crop production (Abbasi, *et al.*, 2013; Bakhsh, *et al.*, 2011; Basuchaudhuri, 2016) and plant quality (Awan, *et al.*, 2015). The GA_3 belongs to the gibberellin which has the function in accelerating germination (Sheykhbaglou, *et al.*, 2014). GA_3 is mostly utilized to increase germination percentage (Chetouani *et al.*, 2017). The applied combination of both compounds is expected to provide better development of mangrove seedling.

Ceriops tagal is among the threatened mangrove species due to coastal degradation. The habitat of *C. tagal* is in the inner mangrove area approaching the dry land (Liao, *et al.*, 2009; Wibisono, 2016). Suitable substrate for *C. tagal* growth is sandy mud with the salinity range of 0-15 ppt (Duke *et al.*, 2010). The intensive upland development and increasing coastal degradation had caused the distribution of *C. tagal* to be limited. Plantation of *C. tagal* had showed lower establishment level compared to its natural germination (Mukhlisi & Gunawan, 2016). Thus, *C. tagal* needs to be protected from further loss and should be breeded to increase its abundance.

The application of plant growth regulator is rarely done on the improvement of plant quality, especially for mangrove. Even though, the impact of this method needs to be understood to achieve alternate solution on plantation problems. In order to formulate the appropriate solution for *C. tagal* adaptability improvement, a research needs to be conducted. This research aimed to study the effect of plant growth regulator on the growth of *C. tagal* seedling and to formulate the best appli-

cable treatment to improve its growth performance. This research is expected to provide technical recommendation on the application of PGRs to improve the growth of C. tagal. Thus, the seeding could be conducted more effectively.

METHODS

Time and location

This research was conducted in the greenhouse laboratory of Faculty of Science and Mathematics Diponegoro University from August to September 2017.

Experiment design

Experimental design involved the application of plant growth regulator through the combination of NAA and GA_3. The treatments included the concentration of 0 ppm, 150 ppm, and 300 ppm of the regulator. The treatment without NAA and GA_3 (0 ppm) acted as the control. The complete experiment design is described as follows:

N0G0 (control) = without NAA and GA_3
N0G1 = only 150 ppm GA_3
N0G2 = only 300 ppm GA_3
N1G0 = only 150 ppm NAA
N1G1 = 150 ppm NAA + 150 ppm GA_3
N1G2 = 150 ppm NAA + 300 ppm GA_3
N2G0 = only 300 ppm NAA
N2G1 = 300 ppm NAA + 150 ppm GA_3
N2G2 = 300 ppm NAA + 300 ppm GA_3

Treatment activities

The mangrove species utilized in this research was *Ceriops tagal* seedling which had a couple of leaf. The seedling was planted in the polybag under the greenhouse. The plant growth regulator was given to the mangrove seedling during the experiment by spraying on its plant surface (leaf and trunk) every three days with three sprays. The experiment was conducted for one month which involved 4 observation periods with one week interval.

Data collection and analysis

Data collected were included the survival rate, height increment, and leaf development. Height increment was analyzed with factorial ANOVA to understand the both partial and simultaneous effect of plant growth regulators. Analysis factors included the concentration of NAA and GA_3.

RESULTS AND DISCUSSIONS

The experiment indicated that *C. tagal* seedlings responded the PGR application. The variations of survival rate, height increment and leaf development were observed during the research. These parameters showed the most appropriate treatment to improve the seeding application. Each parameter plays important role in the development of mangrove plants. The survival rate indicates the capability of mangrove seedling to establish and become the most important factor in the seed production. The height increment plays important role in defining its growth, which then determine its ecological value. The leaf development is an important aspect of plants metabolism which plays important role in supporting plant growth.

The survival rate indicates the environmental suitability for seedling growth. Unsuitable condition would increase plant stress and mortality. The application of PGR was expected to favor mangrove seedling due to unsuitable environmental condition. The survival rate of *C. tagal* seedling during the research was noticable. The observation showed the gradually decrease of seedling survival rate among weeks. Some treatments showed extreme survival decrease after one month of experiment. Detailed survival rate of *C. tagal* during the research is presented in Table 1.

Table 1. Cummulative survival rate of *C. tagal* treated with plant growth regulator

Treatment	Week of Observation (%)			
	I	II	III	IV
N0G0	100	60	40	20
N1G0	100	80	40	20
N2G0	100	80	60	60
N0G1	100	80	60	40
N0G2	100	80	80	80
N1G1	100	80	80	60
N2G1	100	100	80	60
N1G2	80	60	40	40
N2G2	100	60	60	40
Min	80	60	40	20
Max	100	100	80	80
Average	98	78	62	49

Table 1 showed that the mortality of mangrove seedling had began since the first week, while in the third week seedling mortality was observed at all treatments. Among the applied treatments, the control (N0G0) and N1G0(150 ppm NAA) had the lowest final survival rate compared to any other treatments. The survival of *C. tagal* in treatment N2G1 (300 ppm NAA + 150 ppm GA_3) was great during the early period, then gradually decreased. The maximum survival was achieved from treatment N0G2 (300 ppm GA_3), which could maintain long term survival. This result indicated that the application of 300 ppm GA_3 could improve the adaptability of *C. tagal* seedling.

The height increment of mangrove seedling indicates the environmental support for plant growth. Height increment data processing was conducted for periodic growth and cummulative growth. Periodic height increment indicated the effect of the PGR on the growth rate of mangrove seedling. Observation on the periodic height increment of *C. tagal* during the research is presented in Table 2.

The periodic growth increment as shown in Table 2 indicated that the growth rate of *C. tagal* seedling was fluctuative. The optimum growth rate dynamically changed among periods. This result showed that there was no particular effect of the treatment on the growth rate of *C. tagal* seedling. Data analysis which was conducted with ANOVA showed that there was no significant neither particular nor simultaneous effect of PGRs on the growth rate of *C. tagal*. Analysis on the effect of NAA showed the calculated F value of 0.584 with the probability of 0.559, while the effect of GA_3 showed the F value of 0.637 and probability of 0.530. Simultaneous effect of both PGR resulted the F value of 0.338 and probability of 0.852.

Cumulative height increment among periods indicated the total growth of plants in relative to its initial height. The difference of periodic growth rate of mangrove might bo so low, thus it was not significant. However, the cummulative growth might show different pattern. The significant difference could be of the growth might be noticable after a several periods. Table 3 shows the cummulative growth of *C. tagal* seedling during the research.

Table 3 shows that there is a noticable difference of final height increment of *C. tagal* among treatments. Highest increment is achieved from treatment N0G1 (150 ppm GA_3), while the lowest is achieved from treatment N1G2 (150 ppm NAA + 300 ppm GA_3). This indicates that increasing PGR concentration does not always lead to the higher plant growth. Data analysis

Table 2. Periodic height increment of *C. tagal* treated with plant growth regulator

Treatment	Value	Week of Observation											
		I			II			III			IV		
N0G0	Range	0.1	-	2.5	0.6	-	1.8	0.6	-	2.1	0.9	-	1.6
	Average	1.06	±	1.19	1.10	±	0.62	1.15	±	0.66	1.20	±	0.32
N1G0	Range	0.3	-	2.2	0.7	-	1.2	0.7	-	1.3	0.9	-	1.4
	Average	0.82	±	0.79	0.93	±	0.26	0.93	±	0.32	1.05	±	0.24
N2G0	Range	0.3	-	2.2	0.1	-	3	0.1	-	2	0.2	-	2
	Average	1.02	±	0.79	1.28	±	1.25	0.88	±	0.84	0.94	±	0.68
N0G1	Range	0.5	-	2	0.2	-	1	0.2	-	1.9	0.5	-	1.2
	Average	1.00	±	0.71	0.80	±	0.40	1.08	±	0.70	0.93	±	0.34
N0G2	Range	0.1	-	1.3	0.5	-	1.7	0.9	-	1.1	0.7	-	1.9
	Average	0.58	±	0.58	0.85	±	0.57	1.03	±	0.10	1.32	±	0.51
N1G1	Range	0.6	-	2.3	0.9	-	1.3	0.6	-	1.8	0.2	-	1.1
	Average	1.06	±	0.70	1.10	±	0.18	1.06	±	0.45	0.65	±	0.47
N2G1	Range	0.1	-	1.9	0.3	-	1.6	0.2	-	1.5	0.7	-	2.6
	Average	0.82	±	0.69	0.88	±	0.48	0.83	±	0.54	1.43	±	0.85
N1G2	Range	0.1	-	1	0.1	-	0.8	0.5	-	1.4	0.2	-	2.2
	Average	0.38	±	0.42	0.48	±	0.30	0.98	±	0.49	0.94	±	0.78
N2G2	Range	0.2	-	0.6	1	-	1.5	0.5	-	1.9	0.4	-	2.6
	Average	0.40	±	0.16	1.30	±	0.26	0.92	±	0.60	1.18	±	0.98

Table 3. Cummulative height increment of *C. tagal* treated with plant growth regulator

Treatment	Value	Week of Observation											
		I			II			III			IV		
N0G0	Range	0.1	-	2.5	0.7	-	2.2	2	-	2.8	3.3	-	3.3
	Average	1.06	±	1.19	1.30	±	0.79	2.40	±	0.57	3.30	±	--
N1G0	Range	0.3	-	2.2	1	-	1.7	2.3	-	2.7	4.1	-	4.1
	Average	0.82	±	0.79	1.40	±	0.29	2.50	±	0.28	4.10	±	--
N2G0	Range	0.3	-	2.2	1.6	-	4.1	2	-	3.9	3	-	4.4
	Average	1.02	±	0.79	2.48	±	1.12	3.07	±	0.97	3.90	±	0.78
N0G1	Range	0.5	-	2	1.5	-	3	2.9	-	3.4	4.1	-	4.4
	Average	1.00	±	0.71	1.93	±	0.72	3.17	±	0.25	4.25	±	0.21
N0G2	Range	0.1	-	1.3	0.6	-	3	1.7	-	3.9	2.6	-	5.8
	Average	0.58	±	0.58	1.50	±	1.12	2.53	±	1.05	4.00	±	1.44
N1G1	Range	0.6	-	2.3	1.5	-	2.1	2.1	-	3.9	3.2	-	4.1
	Average	1.06	±	0.70	1.85	±	0.26	2.95	±	0.75	3.57	±	0.47
N2G1	Range	0.1	-	1.9	0.9	-	3.5	1.1	-	2.9	3.2	-	3.7
	Average	0.82	±	0.69	1.70	±	1.03	2.08	±	0.75	3.47	±	0.25
N1G2	Range	0.1	-	1	0.6	-	0.9	2	-	2.3	2.2	-	3.4
	Average	0.38	±	0.42	0.77	±	0.15	2.15	±	0.21	2.80	±	0.85
N2G2	Range	0.2	-	0.6	1.3	-	2	2.3	-	3.9	2.7	-	5
	Average	0.40	±	0.16	1.67	±	0.35	2.87	±	0.90	3.85	±	1.63

by using anova showed that cummulative height increment was significantly different at the third and fourth observation compared to the first observation. However, there was no significant different between neither the second to the third and fourth, nor third to fourth observtions. The NAA and GA_3 on the cummulative height increment are not significant neither partially nor simultanously.

The analysis of the periodic difference showed that F value of 4.173 and probability 0.007. Factorial analysis on the effect of NAA partially resulted the F value of 1.172 and probability of 0.313, while the GA_3 resulted the F value of 1.837 and probability of 0.163. The simultanous analysis showed the F value of 2.363 and probability of 0.056. Thus, the addition of PGR on seedling for 1 month did not give significant effect on the height increment of *C. tagal* seedling. However, the cumulative growth was noticable.

The last parameter observed in this research was the leaf development. Faster leaf development should improve seedling establishment through metabolism process. Thus, the application of PGR was expected to stimulate the leaf development of *C. tagal* seedling during the experiment. The observation result of cummulative leaf development during the research is presented in Table 4.

The observation result of leaf development as presented in Table 4 shows that the maximum leaf development during 1 month experiment is 2 leaves. Early leaf development is observed from treatment N0G1 (150 ppm GA_3) and N1G1 (150 ppm NAA + 150 ppm GA_3) in the first period. However, the final observation shows that highest average of leaf development is achieved from treatment N0G2 (300 ppm GA_3). The high leaf development avarage value in the treatment N0G0 (control) and N1G0 (150 ppm NAA) was due to its low survival which was only one seedling stand remain in the last observation.

The combination of the analysis result showed that the best treatment to improve the seedling growth quality of *C. tagal* was N0G2 (300 ppm GA_3). Instead of its best survival compared to the other treatments, it also provided a good final growth. The final observation of this treatment showed the survival of 80% and height increment of 4 cm. The second potential treatment was N2G0 (300 ppm NAA) which had lower survival and growth with the level of 60% and 3.9 cm respectively.

In order to grow optimally, a balanced nutrient supply is required by plants as well as hormonal stimulation in the PGR application.

Table 4. Cummulative leaf development of *C. tagal* treated with plant growth regulator

Treatment	Value	Week of Observation											
		I			II			III			IV		
N0G0	Range	0.0	-	1.0	0.0	-	2.0	0.0	-	2.0	2.0	-	2.0
	Average	0.2			0.7			1.0			2.0		
N1G0	Range	0.0	-	0.0	0.0	-	2.0	0.0	-	2.0	2.0	-	2.0
	Average	0.0			1.0			1.0			2.0		
N2G0	Range	0.0	-	0.0	0.0	-	2.0	0.0	-	2.0	0.0	-	2.0
	Average	0.0			0.5			0.7			0.5		
N0G1	Range	0.0	-	2.0	0.0	-	2.0	0.0	-	2.0	0.0	-	2.0
	Average	0.4			0.5			1.3			1.3		
N0G2	Range	0.0	-	0.0	0.0	-	2.0	0.0	-	2.0	0.0	-	2.0
	Average	0.0			1.0			1.0			1.5		
N1G1	Range	0.0	-	2.0	0.0	-	0.0	0.0	-	0.0	0.0	-	2.0
	Average	0.4			0.0			0.0			1.0		
N2G1	Range	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	2.0
	Average	0.0			0.0			0.0			0.7		
N1G2	Range	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	2.0
	Average	0.0			0.0			0.0			0.5		
N2G2	Range	0.0	-	0.0	0.0	-	0.0	0.0	-	0.0	0.0	-	2.0
	Average	0.0			0.0			0.0			0.5		

Imbalanced hormone might cause plant stress or unexpected growth pattern. In order to achieve expected plant growth, the existing growth media should be considered. Plants might show different growth pattern on the different soil condition due to its nutrient availability. Particular application of PGR was also used to increase the efficiency of certain fertilizer application (Otie, *et al.*, 2016). Thus, the utilization of PGR treated seed are usually followed by strict fertilization treatment. The application of PGR was also utilized to improve plants adaptabitlity in certain environment condition (Schiavon, *et al.*, 2014).

This research proved that the application of PGR could increase the survival and growth of *C. tagal* seedling. Observation on the control treatment (without PGRs) resulted the survival of only 20% and final height increment of 3.3 cm for 1 month. This result was extremely low. Thus, in order to improve the seeding activity of *C. tagal*, the application of PGR is requred. However, the combination of both PGRs seemed to be ineffective. The survival and height increment of all mixed PGRs were lower than the application of particular GA_3 and NAA. The analysis also indicated that the effective concentration of PGRs application on *C. tagal* seedling was 300 ppm.

In optimum growth of *C. tagal* seedling in the mixed PGR treatment might be caused by its inappropriate planting media. Lack of nutrient caused the poor organ formation and growth of the plant (José, *et al.*, 2012). In this research, plants which were grown in the polybags had limited nutrient sources. Thus, the growth of *C. tagal* seedling in the PGR applied treatments were also limited. Plant stress also affect the distribution of hormone into particular organs (Rowe, *et al.*, 2016). Particular hormone should be accumulated in the particular organs in order to stimulate its growth and optimize its function (Krouk *et al.*, 2010). Thus, the growth could not be optimized.

Auxin and gibberellin are utilized to control the quality of fruit production (Suman, *et al.*, 2017). Even though, the application of PGR does not always resulted in better plant growth. The application of NAA could even decrease plat's height, but increase its fruit productivity, shorten fruit maturity and increase the yield (Abbasi *et al.*, 2013). The gibberellin plays important role in the germination of dormant seed (Chen, *et al.*, 2008). In this research, 300 ppm GA_3 application showed the best growth survival and good but not best final height increment of *C. tagal* seedling. The role of GA_3 included the minimization of salinity stress on plants (Sahil, 2016), thus *C. tagal* could grow better than the other plants in

the salinity stressed environment such as coastal area. This result showed that there was a possibility of improving *C. tagal* survival and growth during the plantation in the coastal area through the treatment of GA_3.

Even though the PGR could be applied to improve the productivity of plants, there are limitation on the utilization. Excessive concentration of particular PGR might bring up phytotoxicity effect (Almeida, *et al.*, 2016). Thus, the concentration should be properly understood to achieve optimum result.

This research provide a novel finding concerning the application of PGRs on the in vivo seedling plantation of *C. tagal*. The utilization of GA_3 or NAA is preferred than the combination of both PGRs in order to improve seedling growth. This research also found that the higher concentration of PGRs would lead to the better seedling growth. However, the optimum limit is not yet known due to data limitation.

This result implies that the growth *C. tagal* seedling could be improved by periodic spraying of GA_3 or NAA to the plant's surface during the seeding process. Current suggested concentration is 300 ppm every 3 days. This method might help mangrove seed farmers to improve the productivity and quality of mangrove seedling, especially *C. tagal*. However, neither higher concentration nor more frequent spraying is not recommended since the impact is not known yet.

CONCLUSIONS

The application of PGRsdid not effect the survival, height increment and leaf number development of C. tagal significantly. The best growth performance was achieved from the treatment with 300 ppm of GA_3.

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REFERENCES

Abbasi, N. A., Zafar, L., Khan, H. A., & Qureshi, A. A. (2013). Effects of Naphthalene Acetic Acid and Calcium Chloride Application on Nutrient Uptake, Growth, Yield and Post Harvest Performance of Tomato Fruit. *Pakistan Journal of Botany*, *45*(5), 1581–1587.

Almeida, O. M. De, Melo, H. C. De, & Portes, T. D. A. (2016). Growth and Yield of the Common Bean in Response To Combined Application of Nitrogen and Paclobutrazol. *Revista Caatinga*, *29*(1), 127–132. http://doi.org/10.1590/1983-21252016v29n115rc

Andradi-Brown, D. A., Howe, C., Mace, G. M., & Knight, A. T. (2013). Do Mangrove Forest Restoration or Rehabilitation Activities Return Biodiversity to Pre-Impact Levels? *Environmental Evidence*, *2*(1), 20.

Awan, D. A., Ahmad, F., & Ashraf, S. (2015). Naphthalene Acetic Acid and Benzylaminopurine Enhance Growth and Improve Quality of Organic Spinach in Kitchen Gardens. *Journal of Bioresource Management*, *2*(3), 30–37.

Bakhsh, I., Khan, H. U., Khan, M. Q., & Javaria, S. (2011). Effect of Naphthalene Acetic Acid and Phosphorus Levels on the Yield Potential of Transplanted Coarse Rice. *Sarhad Journal of Agriculture*, *27*(2), 161–165.

Bashan, Y., Moreno, M., Salazar, B. G., & Alvarez, L. (2013). Restoration and Recovery of Hurricane-Damaged Mangroves Using the Knickpoint Retreat Effect and Tides as Dredging Tools. *Journal of Environmental Management*, *116*, 196–203. http://doi.org/10.1016/j.jenvman.2012.11.045

Basuchaudhuri, P. (2016). 1-Naphthaleneacetic Acid in Rice Cultivation. *Current Science*, *110*(1), 52–56.

Chen, S.-Y., Kuo, S.-R., & Chien, C.-T. (2008). Roles of Gibberellins and Abscisic Acid in Dormancy and Germination of Red Bayberry (*Myrica rubra*) Seeds. *Tree Physiology*, *28*(9), 1431–1439.

Chetouani, M., Mzabri, I., Aamar, A., Boukroute, A., Kouddane, N., & Berrichi, A. (2017). Effect of Gibberellic Acid (AG3) on the Germination of Seeds of *Thymus satureioides* L and Lavandula dentata. *Journal of Materials and Environmental Sciences*, *8*(3), 942–948.

Cortina, J., Vilagrosa, A., & Trubat, R. (2013). The Role of Nutrients for Improving Seedling Quality in Drylands. *New Forests*, *44*, 719–732. http://doi.org/10.1007/s11056-013-9379-3

Cunha-Lignon, M., Mahiques, M. M., Schaeffer-Novelli, Y., Rodrigues, M., Klein, D. A., Goya, S. C., … Dahdouh-Guebas, F. (2009). Analysis of Mangrove Forest Succession, Using Sediment Cores: A Case Study in the Cananeia-Iguape Coastal System, Sao Paulo-Brazil. *Brazilian Journal of Oceanography*, *57*(3), 161–174. http://doi.org/10.1590/S1679-87592009000300001

Duke, N., Kathiresan, K., Salmo III, S. G., Fernando, E. S., Peras, J. R., Sukardjo, S., & Miyagi, T. (2010). *Ceriops tagal*. *The IUCN Red List of Threatened Species 2010*. Retrieved from http://www.iucnredlist.org/details/178822/0

Giron, D., Frago, E., Glavarec, G., Pieterse, C. M. J., & Dicke, M. (2013). Cytokinins as Key Regulators in Plant – Microbe – Insect Interactions: Connecting Plant Growth and Defence. *Functional Ecology*, *27*, 599–609. http://doi.org/10.1111/1365-2435.12042

José, M. C. S., Romero, L., & Janeiro, L. V. (2012). Effect of Indole-3-Butyric Acid on Root Formation in *Alnus glutinosa* Microcuttings. *Silva Fennica*, *46*(5), 643–654.

Krouk, G., Lacombe, B., Bielach, A., Perrine-Walker, F., Malinska, K., Mounier, E., Gojon, A. (2010). Nitrate-Regulated Auxin Transport by NRT1.1 Defines A Mechanism for Nutrient Sensing in Plants. *Developmental Cell*, *18*(6), 927–937. http://doi.org/10.1016/j.devcel.2010.05.008

Lageweg, W. I. Van De, & Slangen, A. B. A. (2017). Predicting Dynamic Coastal Delta Change in Response to Sea-Level Rise. *Journal of Marine Science and E*, *5*(24), 1–12. http://doi.org/10.3390/jmse5020024

Liao, P.-C., Chiang, Y.-C., Huang, S., & Wang, J.-C. (2009). Gene Flow of *Ceriops tagal* (Rhizophoraceae) Across the Kra Isthmus in the Thai Malay Peninsula. *Botanical Studies*, *50*(2), 193–204.

Mukhlisi, & Gunawan, W. (2016). Regenerasi Alami Semai Mangrove di Areal Terdegradasi Taman Nasional Kutai. *Jurnal Penelitian Kehutanan Wallacea Agustus*, *5*(2), 113–122. http://doi.org/10.18330/jwallacea.2016.vol5iss2pp113-122

Munandar, Sarno, Suwignyo, R. A., Okimoto, Y., & Nose, A. (2014). Growth Evaluation of Rehabilitated Mangroves in Indonesia with Special Emphasis on Relationship with Soil and Hydrological Conditions. *Journal of Agricultural Economics, Extension and Rural Development*, *1*(8), 128–137.

Otie, V., Ping, A., John, N. M., & Eneji, A. E. (2016). Interactive Effects of Plant Growth Regulators and Nitrogen on Corn Growth and Nitrogen Use Efficiency. *Journal of Plant Nutrition*, *39*(11), 1597–1609. http://doi.org/10.1080/01904167.2016.1161779

Ren, G., Liu, X., & Shi, Y. (2011). Effects of Plant Growth Regulator S-Y on Diurnal Changes in Photosynthetic Parameters and Yield of *Stevia rebaudina* Bertoni. *Energy Procedia*, *5*, 429–434. http://doi.org/10.1016/j.egypro.2011.03.074

Rowe, J. H., Topping, J. F., Liu, J., & Lindsey, K. (2016). Abscisic Acid Regulates Root Growth Under Osmotic Stress Conditions Via An Interacting Hormonal Network with Cytokinin, Ethylene and Auxin. *New Phytologist*, *211*, 225–239. http://doi.org/10.1111/nph.13882

Sahil, A. A. Al. (2016). Effect of Gibberellic and Salicylic Acids Pre-Soaking on Seed Germination Attributes of Cucumber (*Cucumis sativus* L.) under Induced Salt Stress. *Cercetari Agronomice in Moldova*, *49*(1), 99–109. http://doi.org/10.1515/cerce-2016-0009

Saputro, T. B., Finariyah, F., Dianawati, S., Sholihah, N. F., & Ermavitalini, D. (2016). In Vitro Selection of Local Maize (*Zea mays*) on NaCl Stress and Its Genetic Characterization Using RAPD. *Biosaintifika*, *8*(3), 344–351. http://doi.org/10.15294/biosaintifika.v8i3.6934

Sari, N., Suwarsi, E., & Sumadi. (2014). Optimasi Jenis dan Konsentrasi ZPT dalam Induksi Kalus Embriogenik dan Regenerasi Menjadi Planlet pada *Carica puberscens* (Lenne & K.Koch). *Biosaintifika*, *6*(1), 51–59.

Schiavon, M., Leinauer, B., Serena, M., Maier, B., & Sallenave, R. (2014). Plant Growth Regulator and Soil Surfactants' Effects on Saline and Deficit Irrigated Warm-Season Grasses: II. Pigment Content and Superoxide Dismutase Activity. *Crop Science*, *54*(6), 2827–2836. http://doi.org/10.2135/cropsci2013.10.0708

Shahbudin, S., Zuhairi, A., & Kamaruzzaman, B. Y. (2012). Impact of Coastal Development on Mangrove Cover in Kilim River, Langkawi Island, Malaysia. *Journal of Forestry Research*, *23*(2), 185–190. http://doi.org/10.1007/s11676-011-0218-0

Sheykhbaglou, R., Rahimzadeh, S., Ansari, O., & Sedghi, M. (2014). The Effect of Salicylic Acid and Gibberellin on Seed Reserve Utilization, Germination and Enzyme Activity of Sorghum (*Sorghum bicolor* L.) Seeds Under Drought Stress. *Journal of Stress Physiology & BIochemistry*, *10*(1), 5–13.

Sofawi, A. B., Rozainah, M. Z., Normaniza, O., & Roslan, H. (2017). Mangrove Rehabilitation on Carey Island, Malaysia: An Evaluation of Replanting Techniques and Sediment Properties. *Marine Biology Research*, *13*(4), 390–401. http://doi.org/10.1080/17451000.2016.1267365

Suman, M., Sangma, P. D., Meghawal, D. R., & Sahu, O. P. (2017). Effect of Plant Growth Regulators on Fruit Crops. *J. Pharmacogn. Phytochem.*, *6*(2), 331–337. Retrieved from http://www.phytojournal.com/archives/2017/vol6issue2/PartF/6-2-70-493.pdf

Wibisono, I. T. C. (2016). *Kajian Kelayakan dan Pengembangan Desain Teknis Rehabilitasi Pesisir di Sulawesi Tengah* (No. 227). Bogor, Indonesia.

Zayova, E., Vassilevska-Ivanova, R., Kraptchev, B., & Stoeva, D. (2012). Indirect Shoot Organogenesis of Eggplant (*Solanum melongena* L.). *Journal of Central European Agriculture*, *13*(3), 446–457. http://doi.org/10.5513/JCEA01/13.3.1070