Growth inhibition of acacia (Acacia nilotica) with seawater and shade

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Abstract. This research investigated the effect of the concentration of seawater (AL) and light intensity on seedling growth of A. nilotica. The research method used a randomized block design (RBD) factorial design with two factors. The first factor is seawater with 6 levels of concentration (AL 0%, 20% AL, AL 40%, AL 60%, 80% AL and AL 100%). The second factor is the shade with three levels of shade (55% NG, NG 65%, and 75% NG). The results showed: (1). Single factor shade and seawater has an inhibitory effect on the percentage of deaths tillers of A. nilotica, each treatment have different effects. The most effective combination inhibited A. nilotica growth was NG3AL5 (shade 75% and 100% concentration of seawater). (2). Seawater treatment affects the tissue organ damage of A. nilotica plants, especially roots and stems, therefore at 14 MST most of the test plants die for not being able to tolerate the treatment, (3). The analysis results of the soil physical and chemical parameters showed that no symptoms of poisoning the soil due to seawater treatment in the test medium, as shown by the high levels of every physical and chemical parameter of land far above the exposure limit.

1. Introduction
The presence of acacia plant (A. nilotica) in Baluran National Park in East Java is seen as a weed is very worrying that it becomes a threat to the preservation of grassland communities in the area. Therefore urged to address one alternative that can be done is to break the cycle of life that is by inhibiting the germination and seedling growth of A. nilotica in laboratory scale and field scale [1].

A. nilotica invasion led to the growth of grass pressed, therefore are considered inadequate from the aspect of food availability for herbivorous. Hence, the animals search for other alternatives food, one of which is the leaves and seeds of A. nilotica. However, as the primary food source, the grass cannot be replaced [2,3]. This phenomenon would result in Baluran National Park disruption of ecosystem balance, for example, reduced and the shrinking of the leading herbivorous food. The open areas were burned a few months or a year before [4]. It is assumed that the banteng grazed A. nilotica pods and dispersed the seeds to many areas including the burnt areas. This condition ultimately threatens the existence of herbivorous animals in the region. Baluran National Park savanna conditions are undergoing a change process from an open ecosystem dominated by Poaceae (grasses) into an area overgrown with very tight A. nilotica, thus forming a closed canopy. As a result, some grass species
are unable to live underneath. That phenomenon probably caused by the competition against the light or the influence of the allelopathy. Therefore, it is necessary to study the life cycle of A. nilotica [5] [6].

One way to inhibit the growth of A. nilotica is to provide growth retardants such as seawater. Moreover, the growth of A. nilotica can be inhibited by providing shade. Solar radiation has three important effects on plant physiological processes, ie (a) The harmful effect of heat exchange with the network environment, the process of transpiration, respiration, biochemical reactions in photosynthesis, and other metabolism process; (b) photochemical effects ie photosynthesis, and (c) morphogenic effects that play a role in the regulation and stimulants in various process plant growth and development. Climatic conditions effect on the pattern of the life cycle of the plant [14].

Given the serious effects of the A. nilotica invasion on pastures community in Baluran National Park in East Java, thus becoming the biggest threat to the preservation of the ecosystem in the region, therefore must be treated seriously and professionally. Thus the results of this study should be able to provide an alternative way to inhibit the life cycle of A. nilotica.

This study is attempting to reveal the physiological properties of A. nilotica as a species that is highly invasive the Baluran National Park pasture community in East Java. The presence of A. nilotica will determine the feeding ground area of bison, deer and other herbivorous. If it is not anticipated immediately, will reduce overall ecosystem quality in the region.

The objectives of this study were (a). Proving the influence of light intensity (shade) to the growth of saplings A. nilotica, (b), proving the combined effect of the provision of seawater and shade on seedling growth of A. nilotica.

2. Method
This research is using a randomized block design (RBD) in a factorial design with two factors. The first factor is seawater with 6 levels of concentration (AL 0%, 20% AL, AL 40%, AL 60%, 80% AL and AL 100%). The second factor is the shade with three levels of shade (55% NG, NG 65%, and 75% NG) [7] [8]. To find out the damage symptoms of the A. nilotica tillers anatomy organ due to the provision of seawater, then samples were taken of the organs include the roots and stems to make sample preparation.

3. Results and Discussion

3.1. Shade and seawater effect toward death percentage of A. nilotica
Observations of mortality percentage of test plants were conducted from 8 weeks after planting (WAP), 10 WAP, 12 WAP and 14 WAP. This was due on the 8 WAP test plant was death. Based on the data in Figure 1, it is known that there is a tendency among the combined treatment and seawater shade percentage of the death of the test plants. Generally on the 8 WAP, the highest percentage of death of the test plants at treatment NG3AL2, NG3AL3, NG3AL5. Similarly with NG2AL4, NG1AL4, NG1AL5, and NG0AL4 treatment. Thus, the treatment combination of shade and seawater at 8 WAP observation caused some plants death. This indicates that on 8 WAP, some test plant is not tolerant to the treatment.

Observations at ten wap showing the number of death test plants multiply, especially in the treatment NG3AL1 up to NG3AL5. In 12 WAP and 14 WAP observation indicates the fact that most of the test plants were not able to live on the treatment tested, except the remaining controls on the test plants, ie NG0AL0, NG0AL1, and NG0AL2 treatment. This indicates that the tolerance limits of the treatment plant are tested only on 8 WAP; afterward, the fewer the test plants that have a tolerance to the treatments tested. Thereby, it can be argued that one of the alternatives to killing A. nilotica tillers is by using a shade (55%, 65% and 75%) and seawater (concentration of 20%, 40%, 60%, 80%, and 100%). However, to apply it, necessary to consider the ecological effects inflicted, since the use of seawater in a concentration of NaCl the long term may contribute to the damaging effects (poison) on soil fertility.
The light effects on the death of the test plants can be explained as follows, light acts as a provider of ATP and NADPH required for tethering and reduction of CO₂. Moreover, the light regulates the activity of several photosynthetic enzymes in the chloroplasts. The enzyme is present in an active form when there is a light and inactive or less active form when it is dark. Carbohydrate production of CO₂ is inhibited at all at night because the enzyme is inactive, stomata are closed and the cell-deficient of ATP and NADPH [9]. This fact occurs at observation 14 MST, with the combined treatment NG3AL0 (75% shade and seawater concentration 0%) lead the test plants to die completely. Thus, the 75% shade effective in killing the A. nilotica. These symptoms indicate that A. nilotica is intolerant of shade. Facts on the field showing the same symptoms, as A. nilotica were not able to live in the shade of the forest.

NaCl effect on the A. nilotica deaths percentage can be explained that when the roots are exposed to saline conditions, the water potential of media to below so that the test plants difficult to obtain water and nutrients. This was due to the potential gradient of water between plant roots with the media to be low so that the rate of water and nutrients transport to the top decreased. This will indirectly result in barriers to shoots growth because water and nutrients were materials required for photosynthesis. The decrease in the rate of water transport causes the test plant turgor cell decreases. Turgor is a requirement for cell elongation and growth. Extensibility at the end of the cell, the cell turgor, nor the minimum threshold for enlargement cell turgor, determine the amount of growth that occurs [10,11]. According to Caggrove and Barlow, decrease in cell elongation and growth inhibition when the plants are seized with salt or drought, more influenced by cell extensibility [12]. Therefore, if the extensibility cells decrease, the plant growth will be hampered. To keep growth persists, then the plant can increase the number of major components, regulate cell turgor and wall extensibility. Thus when are treated with NaCl continuously, then the plants will be stressed throughout life, it will cause the death of the test plants (Figure 1).

Soil salinity also inhibits the plants’ growth in many temperate zones, in addition to the desert [9]. Millions of hectares of land are unproductive by the accumulation of salt in the soil. Plants faced two problems in such areas, and the first problem is to obtain groundwater from the negative water potential. The second, vegetation recovering high concentrations of calcium carbonate and chloride ions that possibility toxic. Some crops (e.g. sugar beet, tomato, and rice) are much more tolerant to saline than others (e.g., onions and snow peas) [9]. Some research shows that A. nilotica plants are intolerant of saline treatment on 8 WAP, 10 WAP, 12 WAP and 14 WAP observations, with a concentration of 20% to 100%.

Different phenomena exhibited by halofit regarded as a species saline hoarders. For example, Atriplex triangularis species increasing the osmotic potential becomes small and negative throughout the growing season, is known as a regulator of saline. Wheat derivatives salt-tolerant, e.g. limiting the accumulation of Na + and Cl ions in saline stress compared to culture-sensitive. Bakau (Rhizophoraceae) is another extraordinary example, this plant issued 100% salt capacity.

Combined effect treatment of seawater and shade, showing the mutually reinforcing interaction (synergistic) where the highest percentage of deaths resulting in the combination of the highest shade and the highest concentration of seawater NG3AL5 (75%) shade and the concentration of seawater (100%). The results showed that there were limits to stress tolerance mechanisms in treated test plants, in which with continuous treatment will provide a more powerful impact if it was observed at longer period of time. In other words, the deaths percentage of A.nilotica tillers tend to multiply at longer interval observation.

3.2. Physical and chemical analysis test median after seawater treatment

The results of the analysis of soil fertility after the study (Table 1) shows that the land used is clay, with composition 66% clay, 29% dust and 20% sand. Based on the data in Table 1, can be argued that organic C content of in the planting medium was low in all treatments were tested, including the controls which ranged between 1.39% (NG0AL3) -1.85% (NG0AL5). The content of N-total (%) is relatively low (0.14 to 0.18%), and the C / N ratio in all treatments showed a lower category (9.80-
10.30), it is certainly going to disrupt the growth of the plants. According to Hardjowigeno (2003), N serves to (a) Improving vegetative growth of the plants. Plants that grow in soil with sufficient nitrogen content will be coloured green. Moreover (b) N play a role in protein formation. Further explained that the N-deficient plants show the following symptoms: stunted plant, limited root growth, and the leaves yellow and fall. When this research was conducted, these symptoms can be observed clearly. Especially regarding leaves discoloration turn yellow symptoms and fall, that has occurred at the age of 6 WAP, and increase in number with age of the plant.

P content in control was moderate (16.41 ppm), but the other treatments, e.g., NG0AL1, NG0AL3 and NG0AL5 relatively very low (3.18 to 5.10 ppm). P serves to (a) Cell division, (b) The formation of albumin, (c) The formation of flowers, fruits and seeds, (d) Accelerate ripening, (e) Strengthening the stem so it is not easy to collapse, (f) Root development, (g) Improving the quality of crops, especially vegetables and fodder, (h) Resistant to disease, (i) Forming RNA and DNA, (j) Carbohydrate metabolism, and (k) Store and transfer energy (energy transfer), such as ATP and ADP. Further explained that the P-deficient plants show symptoms as follows: (a). Stunted growth (dwarf), because cell division is disturbed, (b). The leaves become purple or brown from the tip of the leaf, (c). Visible on a young plant, and (d). On corn, corncobs are imperfect, become smaller. The symptoms can be observed clearly on the leaves of seawater treatment. Especially when seawater showed the growth was not optimal. The higher the concentration tested, the greater the inhibitory power, thereby causing the slower growth of the test plants [13].

Ca content of all treatments in the test medium determines the high category (10.87-13.55 me/100 g), except on NG0AL3 treatment, are in the medium category (6.10 me/100 g). Ca serves to (a) preparation of the plant cell wall, (b) cell division, and (c) growth (elongation). Further explained that the Ca-deficient plant show symptoms as follows: (a). Shoots and roots can grow (but can not evolve), and (b). In corn, the ends of the leaves turn brown, folded and droop down conjoined with the leaves underneath. These symptoms can be observed when the research was conducted, where treatment with a high concentration of seawater, for example, NG0AL4 and NG0AL5 (concentration of seawater of 80% and 100%) showed growth of shoots less compared to other treatments, either on observations 2 WAP, 4 WAP, and 6 WAP [13].

Mg content at all treatments at the media test showed moderate category (1.18 me/100g), high (6.26 me/100g) and very high (9.85-13.04 me/100g). Mg serves to (a). Formation of chlorophyll, (b). Enzyme system (activator), and the formation of oil [13]. Further explained that the Mg-deficient plants show symptoms as follows: (a). Mg transported through transport mechanisms within the cell inside the plant, deficiency at the old leaves, (b). The leaves turn to yellow due to the formation of chlorophyll disturbed, (c). On corn leaves, reflecting the yellow stripes, and (d). In the young leaves mucus out (gel), especially when it is already elevated. The symptoms are detected during the research was conducted, especially the leaf colour changes to yellow had occurred at the age of 6 WAP. In further observations, 8 WAP, 10 WAP, 12 WAP and 14 WAP, number of dead plant increasingly in line with the increase in observation time. This is presumably due to the inhibited chlorophyll formation so that the process of photosynthesis does not take place as it should. As a consequence, the plant will die if the condition lasts for an extended period of time.

The K content in all media treatment test showed moderate category (0.57 me / 100 g) to very high (1.81-2.94 me / 100 g). Thus it can be argued that the seawater treatment does not affect the K element in the test medium. It means that the availability of K sufficient for the test plants, but the availability of other elements is not sufficient, then growth remains disturbed (hampered) because every element is synergistically influencing the growth of plants. K serves to (a). Formation of starch, (b). Activate the enzyme, (c). Stomatal opening (regulate breathing and evaporation), (d). Physiological processes in plants, (e). Metabolic processes in the cell, (f). Affect the absorption of other elements, (g). Enhance resistance to drought and disease, and (h) — root development [13].

Na content across all test media treatment showed very high category (15.88-29.59 me/100g), except for controls, are in the low category (0.31 me/00g). According to Salisbury and Ross (1991), high levels of salt in the soil inhibits growth. Plant facing two problems related to the high salt content
in the soil, i.e., (a). Obtaining water from the groundwater potential negative and (b). addressing the high concentration of sodium ions, carbonate and chloride which are toxic to plants. At the time of the study, poisoning symptoms due to seawater treatment have been seen at 6 WAP, where the majority of plants are death. Symptoms of poisoning the heaviest seen in the observations, where almost all of the test plants death, except for a few plants in the control treatment. Thus it can be argued that the seawater treatment is very effective to inhibit seedling growth of *A. nilotica*.

![Figure 1. The effect of the shade and the seawater against the percentage of A. nilotica dead tillers (a). 8 WAP, (b). 10 WAP, (c). 12 WAP, and (d). 14 WAP.](image)

Cation exchange capacity (CEC) on all media treatment test showed a lower category (17.60 me/100g) and moderate (18.25 to 20.24 me/100g) in NG0AL0. Thus, the CEC on test media was not in optimal condition. The cation exchange capacity of a chemical nature is closely related to soil fertility. Soil with a high CEC can absorb and provide better nutrients than soil with a low CEC. This
is due to the nutrients contained in the colloid sorption complex, and then the nutrient elements were easily lost and leached [13].

Soils with organic matter or with high clay content, have a higher CEC than soils with low organic matter or sandy soils. The types of clay minerals determining the CEC, for example, soil with clay mineral montmorillonite, has a greater CEC than soil with a kaolinite clay mineral. Old soils such as Oxisol soil had low CEC because many of its colloid composed of seskuioksida. The amount of CEC, used for land classification identification, for example, Oksisol should have CEC < 16 me/100g clay, while the results of the clay fraction analysis in the test medium indicates the clay content > 51%. Thus it is clear that the CEC test medium is relatively low.

Table 1. Analysis of soil physical and chemical properties at the test medium after the seawater treatment

| Parameter Fraction Texture: | NG0AL0 (Control) | K | NGOAL1 | K | NGOAL3 | K | NGOAL5 | K |
|-----------------------------|-------------------|---|--------|---|--------|---|--------|---|
| 1. Sand (%)                 | 20                | - | 16     | - | 20     | - | 16     | - |
| 2. Dust (%)                 | 17                | - | 19     | - | 29     | - | 18     | - |
| 3. Clay (%)                 | 63                | - | 65     | - | 51     | - | 66     | - |
| C-organic (%)               | 1.85              | R | 1.44   | R | 1.39   | R | 1.60   | R |
| N-total (%)                 | 0.18              | R | 0.14   | R | 0.14   | R | 0.16   | R |
| Ratio C/N                   | 10.30             | R | 10.10  | R | 9.80   | R | 9.80   | R |
| P-available (ppm)           | 16.41             | S | 3.32   | SR| 5.10   | SR| 3.18   | SR|
| (Bray II)                   |                   |   |        |   |        |   |        |   |
| Ca (me/100 g)               | 10.87             | T | 13.15  | T | 6.10   | S | 11.48  | T |
| Mg (me/100 g)               | 1.18              | S | 9.85   | ST| 6.26   | T | 13.04  | ST|
| K (me/100 g)                | 0.57              | S | 1.81   | ST| 2.18   | ST| 2.94   | ST|
| Na (me/100 g)               | 0.31              | R | 15.88  | ST| 27.58  | ST| 29.59  | ST|
| Total Alkali                | 12.92             | - | 40.69  | - | 42.13  | - | 57.07  | - |
| KTK (me/100 g)              | 17.60             | R | 20.23  | S | 18.25  | S | 20.24  | S |
| KB (%)                      | 73.50             | ST| 100    | ST| 100    | ST| 100    | ST|
| Al+ -dd KCI 1 N (me/100g)   | 0.19              | - | 0.15   | - | 0.13   | - | 0.16   | - |
| H+ -dd KCI 1N (me/100g)     | 0.12              | - | 0.09   | - | 0.04   | - | 0.10   | - |
| pH H2O                      | 6.40              | AM| 6.10   | AM| 6.20   | AM| 6.10   | AM|
| pH KCL                      | 6.10              | - | 5.90   | - | 6.10   | - | 6.00   | - |

Notes: NG0AL0 = without seawater (control), NGOAL1 = 20% seawater, NGOAL3 = 40% seawater, dan NGOAL5 = 100% seawater. SR = Very Low, R = Low, S = Medium, T = High, dan ST = Very High. AM = Slightly Sour, K = Category

The measurement results of land base saturation (BS) in all the media's treatment test show that BS is very high (73.50 to 100%). The base cations generally required plant nutrient. Besides, the bases were generally easily leached, so that the soil with a high base saturation indicates that the ground has not experienced a lot of washing and a fertile soil [13]. Soil fertility is closely related to soil pH, where soils with low, medium and high pH, had a high base saturation too. The relationship between pH and BS at 5.5-6.5 pH was almost a straight line. Soils with low base saturation mean having more complex sorption filled by acid cations, i.e. AL+++, and H+. If the amount of acid cation is too much, especially AL +++, it can be toxic to plants. Such a condition found in the acidic soils.

The results of the land pH measurement (H2O) on the entire test media treatment showed that relatively slightly acid pH (6.10 to 6.40). Soil pH having a role to determines the ease of nutrient
elements absorbed by plants. In general, nutrient was easily absorbed by plant roots on around neutral soil pH, because the nutrient most easily soluble in water at this pH. In acid soils, P element can not be absorbed by plants due to bounded (fixed) by Al [13]. In alkaline soil, P element also can not be absorbed by plants as fixed by Ca, indicate the possibility of toxic elements. In acidic soils commonly found Al ions, except fixation element P, also is toxic to the plants. In the marsh soils, the pH is too low (highly acidic) showed high sulfate content, which also is toxic to plants. Besides, the reaction of acidic soil, microelements also becomes soluble, so it is found too many microelements Which influenced the development of microorganisms, that is; bacteria is well developed in a pH of 5.5 or more, while at pH less than 5.5 the development is greatly hampered. The fungus can grow well at all levels of soil acidity. At the pH greater than 5.5 fungi must compete with the bacteria. Nitrogen-fixing bacteria from the air and nitrification bacteria can only well be developed in pH greater than 5.5.

Based on the data in Table 1, indicate that the pH conditions are less supportive of plant growth because it has a slightly sour status. To the condition or can be close to neutral pH or achieve neutral, pH boost can be done by adding lime in the soil so that the function of nutrient absorption can be optimised.

3.3. Seawater treatment effect against A. Nilotica organs tissue damage

Anatomical observation of tissue roots and stems conducted at the end of the experiment (14 WAP). Analysis of the organ tissue damage, based on the overview observed under a microscope to the preparations preserved of each organ tissue. Observation of tissue damage is presented in Figures 2 and 3.

![Figure 2](image_url)

**Figure 2.** The incision anatomical roots of *A. nilotica* after seawater treatment. (A) AL0 = 0% Seawater (control), (b) AL1 = 20% Seawater, (c) AL2 = 40% Seawater, (d) AL 3 = 60% Seawater, (d) AL4 = 80% Seawater, and (e) AL5 = 100% Seawater

Based on Figure 2, it can be shown that the description of the root anatomy varies based on the concentration of seawater given. Better root anatomical features (intact) than others, showed in control. The worst damage to the epidermis is shown in Figure 2e and 2f (treatment of 80% AL and 100% AL). It is suspected that the seawater causes damage to the epidermal tissue root of *A. nilotica.*
Based on Figure 3, it can be shown that the description of the anatomy of the stem varies based on the concentration of seawater given. Stem anatomy has a better illustration (intact) in controls (AL0) than others. The worst damage to the epidermis is shown in Figure 3e and 3f (treatment of 80% AL and 100% AL). It is suspected that the seawater causing damage to the epidermal tissue and the vascular tissue on the stems of *A. nilotica*. Thus it can be argued that the vascular tissue damage caused by physiological processes such as the transport of water and absorption element does not take place as it should. If it lasts for a long period of time, will lead to the death of the test plants. Most of the test plants die at 14 WAP, except the control (without the administration of seawater). The concentration of the soil effect ion variety then impacts on plant development [15].

Effects associated with tissue damage, the last few years the attention devoted to the mechanisms of Ca\(^{2+}\) in overcoming the destructive effects of Na\(^{+}\). For example, corn root growth is very sensitive to NaCl (75 mM) in a nutrient solution, but this can be overcome by adding Ca\(^{2+}\) (10 mM), as long as the Ca\(^{2+}\) is supplied before the sodium. The same evidence through this study supports the claim that Ca\(^{2+}\) protects the membrane from the effects of damaged Na because it maintains the membrane formation and resists leakage of cytosol K\(^{+}\) [9].

![Figure 3. Overview of *A. nilotica* anatomical rod after seawater treatment. (A) AL0 = 0% seawater (control), (b) AL1 = 20% seawater, (c) AL2 = 40% seawater, (d) AL3 = 60% seawater, (d) AL4 = 80% seawater, and (e) AL5 = 100% seawater](image-url)
showed that the Na content on the treatment successively as follows: AL0 = 12560.66 mg/l, AL1 = 2274.18 mg/l, AL2 = 4235.53 mg/l, AL3 = 4575.48 mg/l, AL4 = 12560.66 mg/l, and AL5 = 12261.21 mg/l. Thus it can be argued that the higher the concentration of the seawater given, the higher the Na content in the test medium, and consequently the greater the effect of the damage. Similarly, the content of Cl. In the treatment of AL = 8.0 mg/l, AL1 = 4118.72 mg/l, AL2 = 7797.58 mg/l, AL3 = 10296.81 mg/l, AL4 = 17374.61 mg/l, and AL5 = 12955.98 mg/l.

4. Conclusions
Based on the analysis and discussion, the following conclusions are taken: The single factor shade and seawater has inhibitory effects against the growth parameters, the percentage of A. nilotica deaths. Each treatment gives a different effect. However, the most effective combination inhibited the growth of A. nilotica is NG3AL5 (75% shade and 100% concentration of seawater). There is a mutually reinforcing interaction effect of each of these factors against the growth of A. nilotica. Seawater treatment effect on A. nilotica organ tissue damage, i.e., the roots and stems. Thus at 14 WAP, most of the test plants died as a result of not being able to tolerate the treatment were tested. The results of the soil physical and chemical parameters analysis showed that there are symptoms of poisoning the soil, due to seawater treatment in the test medium. This is shown by the high levels of every physical and chemical parameter, far above the exposure limit.

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