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Efforts to Accelerate the Breaking of Soursop (Annona Muricata L.) Seed Dormancy with Different Concentrations of H_2SO_4 and Giberellin

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ABSTRACT: This study aims to accelerate the dormancy breaking of soursop seeds (Annona muricata L.) with different csoncentrations of H_2SO_4 and Gibberellin. This study used a Completely Randomized Design (RAL) factorial. This study used two factors. The first factor is the concentration of H_2SO_4 consisting of 4 levels, namely: A0 = Control (No Treatment), A1 = H_2SO_4 15% (10 minutes), A2 = H_2SO_4 30% (10 minutes), and A3 = H_2SO_4 45% (10 minutes). The second factor is the concentration of Gibberellin (GA3), consisting of 3 levels, namely: G1 = 200 ppm (12 hours), G2 = 300 ppm (12 hours), and G3 = 400 ppm (12 hours)—data analysis was done using variance analysis and Duncan's test. The results showed that the concentration of H_2SO_4 significantly affected germination power and germination age. Gibberellin concentration had a significant effect on germination power and germination age. The interaction of H_2SO_4 concentration and Gibberellin concentration had no significant effect on germination power or germination age.

Keywords*:* Dormancy, Sulfat Acid, Gibberellin, Soursop Seeds

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INTRODUCTION

The soursop plant (Annona muricata L.) is one of the plants included in the Dicotyledonae class, Annonaceae family, and Annona genus. Soursop comes from Dutch (Zuurzak), which means sour bag. The Dutch East Indies colonial government introduced Soursop to various regions in the archipelago in the 19th century. This plant is included in the type of annual plant that can grow and bear fruit all year round if the growing conditions are met during growth. These regions originate from tropical areas on the American continent, namely the Amazon Forest (United States), the Caribbean, and Central America (Wijayanti, 2019).

Soursop is a plant that can bear fruit and grow well every year if soil moisture is maintained during growth. Soursop belongs to the Annonaceae genus and has the species name Annona muricate Linn. Soursop in Indonesia has several types: queen, common, Bali, Mandalika, and many more. In 2020, soursop production in Indonesia reached 127,845 tons, and in East Java, it reached 40,819 tons (Central Statistics Agency, 2020). Soursop is a superior fruit that is widely favored by the public. Apart from its distinctive taste and aroma, it also contains many vitamins that are very beneficial for body health and have been proven to eradicate cancer.

Soursop production in Indonesia is relatively low because not many farmers are interested in cultivating soursop plants, and it tends to decline because the number of productive plants is decreasing. One of the obstacles in soursop cultivation is the lack of availability of superior seeds in large quantities and at low prices. Soursop seed propagation is still constrained because soursop seeds take a long time to germinate due to physical obstacles, such as the complex and thick seed coat impermeable to water and gas (Syafinas, 2021).

One of the obstacles in soursop cultivation is that the seeds do not germinate immediately (dormant). This is because soursop seeds have thick and problematic skin, and soy is impermeable to water and gas, which causes germination to be hampered or the time needed to induce germination to be longer (Saputra et al., 2017). Dormancy is a condition where seeds are alive but cannot germinate until the final deadline, even though the environmental factors are optimum for germination (Widajati, 2014). According to (Gea & Ginting, 2018), germination of soursop seeds in suboptimal conditions occurs for 2 to 3 months. When soursop seeds are in conditions that meet the growing requirements, soursop germination can occur within 3 weeks. Soursop seeds have a long time to germinate, so a statement is needed to increase the germination rate and percentage of seeds.

One way to break soursop seed dormancy is to use chemicals such as a sulfuric acid solution (H_2SO_4) and nitric acid in concentrated concentrations. This makes the seed coat soft so that water can easily pass through. Nitric acid at a concentration of 0.5% and a soaking time of 72 hours can break soursop seed dormancy faster than other treatments (Utami et al., 2020).

(Junita et al., 2023) assert that dormant seeds, due to their hard exterior, may be viable by dormancy-breaking treatments, namely the processes or circumstances used to expedite seed germination via scarification. Besides scarification therapy, dormancy breaking may be achieved by immersing in chemical solutions like sulfuric and nitric acid. Research findings (Nurhaliza et al., 2023) indicated that the application of H_2SO_4 accelerates the softening of the seed coat, hence facilitating water absorption in the seeds. Applying a 20% concentration for 25 minutes to Arabica coffee seeds (Coffea arabica) may enhance the germination rate of the seeds. Utilizing sulfuric acid at a 20% concentration may induce dormancy break in nutmeg seeds by up to 49.99% during 14 hours of soaking (Latue et al., 2019). A 10% sulfuric acid concentration effectively softens the epidermis of Arabica coffee seeds, facilitating the imbibition process and promoting accelerated development (Lestari & Riza Linda, 2016).

Seeds require water, O2, and moderately warm temperatures for germination. Certain species require special conditions to break dormancy, namely to cause further ripening (readiness to germinate), such as using the growth hormone Gibberellin, which activates hydrolytic enzymes in digestion (Gardner et al., 1991). Treatment of king palm seeds with the administration of Gibberellin hormone at a concentration of 75 ppm showed a higher percentage of live sprouts, namely 32%, than other concentration treatments (Nurshanti, 2013). Based on the background above, it is necessary to research the ability of sulfuric acid and Gibberellin to break soursop seed dormancy.

THEORETICAL REVIEW

Sulfuric Acid (H_2SO_4)

Chemical scarification is the breaking of dormancy using chemical substances such as H_2SO_4, KNO3, and so on. Scarification using sulfuric acid H_2SO_4 gives many good results for germination (Putri, 2022).

(Pratama, 2021)added that H_2SO_4 solution is more often used in breaking seed dormancy with concentration variations depending on the condition of the seeds to be grown. In addition, the length of soaking time must also be considered, as well as the condition of the seed coat or pericarp, so that the combination of both can produce optimal results rather than damage the embryo, which causes the failure of embryo growth. Concentrated sulfuric acid is the most common chemical compound used to overcome seed coat dormancy. This treatment is more effective than hot water soaking for some plant species. The length of soaking time is also adjusted to the condition of the seeds; if the seeds have been stored for a long time, they will take longer to soak in acid than the seeds in fresh condition (Pratama, 2021).

The treatment of seed soaking with H_2SO_4 does not affect the seed germination process, both in hypocotyl conditions and in radicle growth. H_2SO_4 is explained to only affect the softening of the seed coat and does not reach the seed embryo. However, when the concentration and soaking time are incorrect, so that the H_2SO_4 solution enters the seed embryo, the seed embryo will be damaged and cause the seeds not to germinate. The H_2SO_4 solution soaking method can be used to soften hard seed coats. This treatment is unsuitable if applied to seeds with soft skin because they already have permeable properties, causing the acid solution to enter and damage the seed embryo (Pratama, 2021).

Gibberellin

Gibberellin (GA) is a plant growth regulator that may eradicate dormancy in the seed coat and shoots of certain plants, hence expediting germination. A multitude of seeds contains gibberellins, particularly inside the embryo. Upon water absorption, the release of gibberellins from the embryo will prompt the seeds to terminate dormancy and initiate germination (Rachappanavar, 2025). A favorable reaction to GA transpires throughout a broad spectrum, while the auxin response is limited to a small concentration range (Gardner et al., 1991). This aligns with (Kamal et al., 2021) assertion that increased concentrations of GA result in greater heights of cinchona seedlings. (Astutik, 2006) indicated that the application of gibberellin concentration and soaking duration to teak seeds (Tectona grandis L.) significantly influenced germination rates, achieving up to 60% germination by utilizing a combination of 10 ppm gibberellin and a soaking period of 24 hours. Furthermore, (Polhaupessy & Sinay, 2014), indicate that administering a GA concentration of 1000 ppm for a soaking duration of 72 hours might enhance germination efficacy by as much as 83.5% in palm seeds.

METHODOLOGY

This study was performed in the Seed Technology Laboratory of the Universitas Methodist Indonesia, located in Tanjung Sari, Medan Selayang District, Medan City, at an elevation of about 32 meters above sea level (masl). This study aims to accelerate the dormancy breaking of soursop seeds (Annona muricata L.) with different concentrations of H_2SO_4 and Gibberellin. This study used a Completely Randomized Design (RAL) factorial. This study used two factors. The first factor is the concentration of H_2SO_4 consisting of 4 levels, namely: A0 = Control (No Treatment), A1 = H_2SO_4 15% (10 minutes), A2 = H_2SO_4 30% (10 minutes), and A3 = H_2SO_4 45% (10 minutes). The second factor is the concentration of Gibberellin (GA3), consisting of 3 levels, namely: G1 = 200 ppm (12 hours), G2 = 300 ppm (12 hours), and G3 = 400 ppm (12 hours). The parameters used are germination power and age of seedlings. Data analysis was done using variance analysis and the Duncan test.

RESULTS

Germination Power (%)

Data on soursop seed germination power due to H concentration$_s$ $_2$SO4 and Gibberellin. The list of variance analysis shows that the treatment of H_2SO_4 and Gibberellin concentrations significantly affected the germination power of soursop seeds, while the interaction between the two treatments did not significantly affect the germination power. Table 1 presents the average germination power of soursop seeds due to different H_2SO_4 and Gibberellin concentration treatments.

Table 1. Average Germination Power (%) of Soursop Seeds in H Concentration Treatment2SO4 and Gibberellin

Treatment	Germination Power (%)
A0	94.67b
A1	98.67ab
A2	100.00a
A3	100.00a
G1	96.00b
G2	99.00ab
G3	100.00a
$A0G_1$	88.00
$A0G_2$	96.00
$A0G_3$	100.00
$A1G_1$	96.00
$A1G_2$	100.00
$A1G_3$	100.00
$A2G_1$	100.00
$A2G_2$	100.00
$A2G_3$	100.00
$A3G_1$	100.00
$A3G_2$	100.00
$A3G_3$	100.00

Information: Numbers followed by the same letter in the same column mean they are not significantly different in the DMRT test at the 5% test level.

Table 1 indicates that in the H concentration treatment of H_2SO_4, the maximum seed germination efficacy was seen in treatments A3 and A2, which differed considerably from A0 but not significantly from A1. The seed germination efficacy in treatment A2 was markedly different from A0 and A1, although the germination duration in treatment A1 did not substantially vary from A0. Figure 1 illustrates the impact of H_2SO_4 concentration on the germination capacity of soursop seeds.

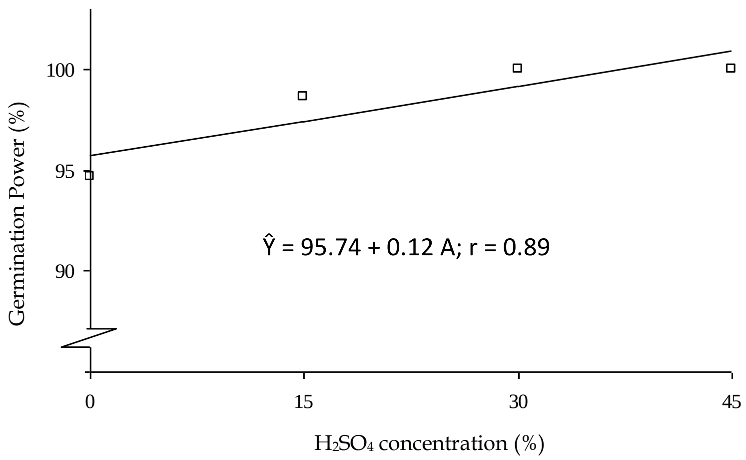

Figure 1. Effect of H Concentration2SO4 on Soursop Seed Germination Power

Figure 1 shows that the higher the concentration of H_2SO_4, the higher the germination power of soursop seeds increases, following a positive linear regression curve. An increase in H_2SO_4 concentration by 1% will increase the germination power of soursop seeds by 0.12%.

Table 1 indicates that the G treatment exhibited the maximum seed germination capacity within the Gibberellin concentration treatment. Substantially distinct from G1, however, not considerably different from G2. The germination capacity of soursop seedlings in the G2 treatment was not markedly different from G1. Figure 2 illustrates the influence of Gibberellin concentration on the germination capacity of soursop seeds.

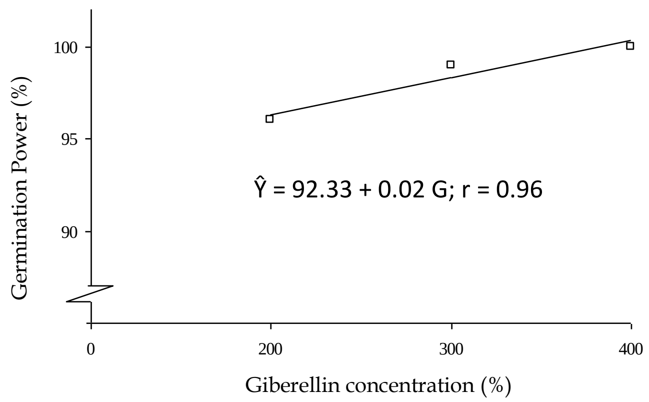

Figure 2. The Effect of Gibberellin Concentration on Soursop Seed Germination Power

Figure 3 shows that the higher the concentration of Gibberellin, the higher the germination power of soursop seeds following a positive linear regression curve. Increasing the concentration of Gibberellinof 1 ppm will increase seed germination power by 0.02%.

Germination Age (days)

Data on the age of soursop seed germination due to H concentration$_2$SO4 and Gibberellin The analysis of variance showed that the treatment of H_2SO_4 and Gibberellin concentrations had a significant effect on the germination age of soursop seeds. In contrast, the interaction between H_2SO_4 and Gibberellin concentrations had no significant effect on the germination age. Table 2 presents the average germination age of soursop seeds due to different H_2SO_4 and Gibberellin concentration treatments.

Table 2. Average Germination Age (days) of Soursop Seeds in H Concentration Treatment$_2$SO4 and Gibberellin

Treatment	Germination Age (day)
A0	23.81a
A1	23.62a
A2	23.00b
A3	23.00b

G1	23.86a
G2	23.32b
G3	22.90c
$A0G_1$	24.13
$A0G_2$	23.86
$A0G_3$	23.44
$A1G_1$	23.99
$A1G_2$	23.64
$A1G_3$	23.24
$A2G_1$	23.72
$A2G_2$	22.84
$A2G_3$	22.44
$A3G_1$	23.60
$A3G_2$	22.92
$A3G_3$	22.48

Information: Numbers followed by the same letter in the same column mean they are not significantly different in the DMRT test at the 5% test level.

Table 2 indicates that in the H concentration treatment2SO4, the most rapid germination of soursop seeds occurred in treatment A3, which was considerably distinct from A0 and A1 but not significantly different from A2. The germination age of seeds in treatment A2 differed considerably from that in A0 and A1, although the germination age in treatment A1 was not statistically different from A0. Figure 3 illustrates the impact of H_2SO_4 concentration on the germination age of soursop seeds.

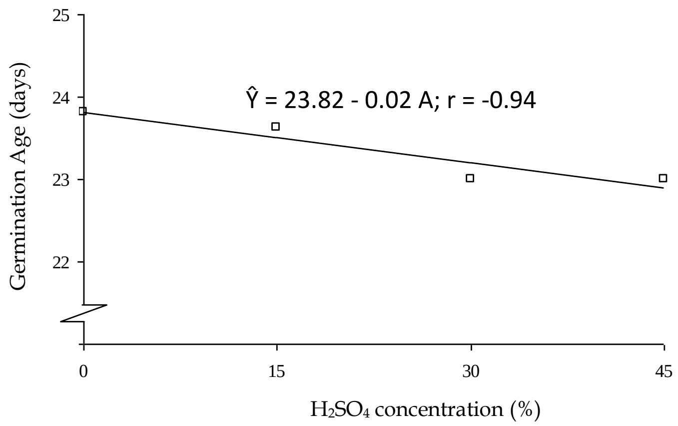

Figure 3. Effect of H Concentration H_2SO_4 on Germination Age of Soursop Seeds

Figure 3 shows that the higher the concentration of H_2SO_4, the faster the age of soursop seed germination is following a negative linear regression curve. An increase in H_2SO_4 concentration by 1% will accelerate the age of soursop seed germination by 0.02 days.

Table 2 indicates that the G treatment exhibited the most rapid seed germination age within the Gibberellin concentration treatment. Substantially distinct from G1 and G2. The age of seed germination in the G2 treatment differed considerably from that in G1. Figure 4 illustrates the impact of Gibberellin concentration on the germination age of soursop seeds.

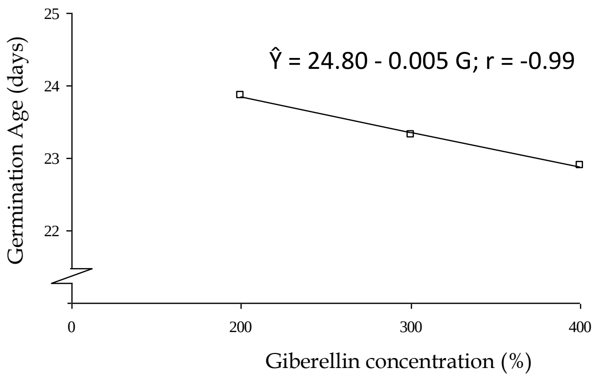

Figure 4. The Effect of Gibberellin Concentration on the Germination Age of Soursop Seeds

Figure 4 shows that the higher the concentration of Gibberellin, the faster the germination age of soursop seeds follows a negative linear regression curve. An increase in Gibberellin concentration by 1 ppm accelerates the germination age of seeds by 0.005 days.

DISCUSSION

Effect of H Concentration₂SO4 on Dormancy Breaking of Soursop (Annona muricata L.)

The results of the study showed that the concentration of H_2SO_4 has a significant effect on the germination power of soursop seeds. The highest germination power was found in treatments A2 and A3 at 100%, while the lowest was in treatment $A._1$by 9.74%. This is because the seeds soaked in the H_2SO_4 solution cause the seed coat to become soft, and water and gas can diffuse into the seed. Softening the seed coat will make it easier for the liquid to enter the seed through the imbibition process, where the more liquid that enters the seed will increase the activity of enzymes that can break down food reserves in the seed so that they can be used for the germination process. The active amylase enzyme will break down starch into glucose; the lipase enzyme breaks down fat into fatty acids and glycerol.

In contrast, the protease enzyme breaks down protein into amino acids. These simple compounds will be transported to the embryo for growth. In addition, the activity of the protease enzyme will produce amino acids beneficial for forming new proteins, such as α-amylase. If the α-amylase enzyme increases, hydrolyzing starch into simple sugars can occur faster. The formation of α-amylase is also influenced by Gibberellin in the embryo. At the beginning of germination, gibberellin acid is activated to form α-amylase. The first organ that appears from the germinating seed is the radicle, which is the embryonic root. The faster the breakdown of food reserves in the seed, the greater the chance of the seed germinating. (Siregar et al., 2022) assert that administering sulfuric acid at an appropriate dosage will effectively weaken the wax coating on the hard seed coat, facilitating water absorption into the seed. The absorption of water by the seed will expedite the development of the radicle and enhance the embryo's growth, hence increasing the germination rate of the seeds.

The study results showed that the concentration of H_2SO_4 significantly affects the germination age of soursop seeds. The fastest germination age was in treatments A2 and A3 at 23 days and the longest in treatment A0 at 23.81 days. Increasing the concentration of H_2SO_4 can accelerate the germination age of soursop seeds. Breaking seed dormancy soaked in an H_2SO_4 solution causes the seed coat to become soft, causing water absorption (imbibition). Imbibition causes the size of the seeds to enlarge (swell) due to the absorption of water into the seeds. Imbibition occurs through the seed coat caused by the difference in potential water pressure inside and outside the seeds, which is called osmotic diffusion, namely the entry of water through a selectively permeable membrane from a high concentration (outside the seed coat) to a low concentration (inside the seed). In addition, water can enter the seeds through the micropyle gap, which is the part that distributes the nutrients in the embryo. Imbibition activates hormones and enzymes that break down nutrients for seed growth so that the meristem tissue absorbs nutrients. This stimulates cell division at the growing point so germination can occur (Anafarida et al., 2021). (Putri, 2022) stated that using H_2SO_4 concentrations up to 60% can accelerate the seed germination process compared to lower concentrations.

The Effect of Gibberellin Concentration on Breaking Dormancy of Soursop Seeds (Annona muricataL.)

The study's results showed that the concentration of Gibberellin significantly affected the germination power of soursop seeds. The highest germination power of soursop seeds was found in the G treatment three at 100% and the lowest in the G1 treatment at 96%. The higher the concentration of Gibberellin, the higher the germination power of soursop seeds. The function of the growth regulator GA3 is to stimulate the biosynthesis of digestive enzymes of food reserves (carbohydrates, proteins, and fats) into simple compounds that will be used as raw materials for respiration for the biosynthesis of biological energy (ATP) which is used for seed life activities including cell division and enlargement to increase germination. The role of the growth regulator GA3 in plants encourages phytohormone activity in seeds so that the ability of seeds to germinate increases (Matanari et al., 2023).

The study's results showed that the concentration of Gibberellin significantly affected the germination age of soursop seeds. The fastest germination age was found in treatment A. 2 and A3 at 23 days and the longest in treatment A1 at 23.86 days. The higher the concentration of Gibberellin, the faster the age of seed germination. Giving Gibberellin will change the amount of internal Gibberellin contained in the seeds. This is the triggering factor for the germination process. Gibberellin acid is diffused into the aleurone layer, where hydrolytic enzymes are made (α-amylase, protease,□□-gluconate, phosphatase).

Hydrolytic enzymes diffuse into the endosperm into sugars, amino acids, and others. These substances all ensure the growth of the seed embryo. Gibberellin also increases the proteinase enzyme, which converts protein into amino acids, and the lipase enzyme, which converts fat into soluble fatty acids and glycerol (Nelvin, 2022). (Matanari et al., 2023) stated that the plant growth regulator gibberellin acid could break certain plant seeds' dormancy or accelerate the germination age.

The Effect of Interaction on H Concentration$_2$SO4 and Gibberellin on Dormancy Breaking of Soursop (Annona muricata L.) Seeds

The study's results showed that the interaction of H concentration$_2$ SO4 and Gibberellin had no significant effect on germination age and germination power. Although the interaction between the two treatments was insignificant, combining H_2SO_4 concentrations could accelerate the breaking of soursop seed dormancy. The use of H_2SO_4 solution is effective in eliminating germination inhibitor compounds, namely ammonia, abscisic acid, ethylene gas, alkaloids, and alkaloid lactones) germination, but also triggers the formation of growth hormones (auxins, cytokinins, gibberellins) so seeds can germinate. The introduction of exogenous Gibberellin in substantial quantities can disturb the equilibrium between auxin and gibberellin hormones, thereby promoting cell elongation, particularly in the meristem or root tips. This occurs because the hydrolysis of starch induced by Gibberellin facilitates the synthesis of α-amylase, resulting in an increased concentration of sugars. This will expedite seed germination (Suradi, 2021).

CONCLUSIONS AND RECOMMENDATIONS

The concentration of H_2SO_4 significantly affected the germination power and germination age. The concentration of Gibberellin significantly affected the germination power and germination age. The interaction of H_2SO_4 concentration and Gibberellin concentration did not significantly affect the germination power and age. Further research is needed to increase Gibberellin concentration to obtain Gibberellin concentration that can increase the germination process of soursop seeds.

FURTHER STUDY

Future research on Indonesia's palm oil exports should consider integrating non-economic variables into the gravity model framework to improve explanatory power and accuracy. Incorporating factors such as trade agreements, tariff and non-tariff barriers, environmental regulations, and political stability could reveal deeper insights into the dynamics of export performance. Moreover, adopting panel data techniques with fixed or random effects models might address heterogeneity among trading partners. The use of machine learning approaches such as Random Forest or Gradient Boosting could also offer predictive modeling benefits by uncovering complex nonlinear relationships between export determinants. Expanding the scope beyond traditional trade partners and including temporal shocks such as global pandemics or geopolitical conflicts would make the model more robust and adaptive to real-world fluctuations in global trade.

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