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The Effect of Salicylic Acid on Two Varieties on the Growth and Production of Rice Plants (*Oryza sativa* L.) in Salin Soil With a Floating Paddy System

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Abstract. This research aims to evaluate the interaction effects and main influences of salicylic acid application and two rice varieties on the growth and yield of rice cultivated in saline soil using a floating rice field system. The study was carried out in the experimental greenhouse of the Faculty of Agriculture, Islamic University of Riau, located on Kaharudin Nasution Street Km 11, Air Dingin Village, Bukit Raya District, Pekanbaru City. The experiment spanned five months, from February to June 2024. A Factorial Completely Randomized Design (CRD) was employed, involving two factors: the first factor was salicylic acid at four concentrations (0, 30, 60, and 90 mg/L of water), while the second factor included two rice varieties, namely Inpari 34 Salin and Batang Piaman. Observed parameters encompassed plant height, flowering time, stomatal count, chlorophyll levels, tiller number, harvest time, panicle length, grain weight, and root volume. Data from the final observations were analyzed statistically using Analysis of Variance (ANOVA), followed by an Honest Significant Difference (HSD) test at a 5% significance level. The results indicated that the interaction between salicylic acid and the two varieties significantly influenced grain weight and root volume. The optimal combination was observed in the Batang Piaman variety treated with 90 mg/L of salicylic acid. Furthermore, the main effect of salicylic acid significantly affected stomatal count and chlorophyll content, with the best outcome achieved at 90 mg/L of salicylic acid. Regarding the variety factor, significant effects were noted for panicle length, grain weight, and root volume, with Batang Piaman emerging as the superior variety. Based on these findings, further studies on floating rice systems using the Batang Piaman variety, known for its salinity tolerance, are recommended to optimize rice production in saline environments.

1. Introduction

Indonesia, with a coastline stretching 99,093 km, has extensive saline land areas influenced by its proximity to the sea (Rachman et al., 2018). Saline soils are predominantly found in coastal regions and result from rising sea levels due to climate change, which increases soil salinity. Salinity is a major challenge to land productivity, exacerbated during the dry season as an impact of global climate change.

Erfandi and Rachman (2011) estimated that saline land in Indonesia spans 440,300 hectares, including 304,000 hectares of slightly saline soil and 140,300 hectares of saline soil. Similarly, Purwaningrahayu and Taufiq (2018) reported a figure of 0.44 million hectares. In contrast, Sodhiq (2020) suggested a lower estimate of 400,000 hectares. Considering the frequency of extreme climatic events over the last two decades, saline land in Indonesia is now projected to have reached approximately 0.6 million hectares.

The expansion of saline land poses a significant threat to agricultural development in many countries, including Indonesia. The exact extent of saline land remains unclear due to variations in data reported by researchers and institutions. High salinity leads to ion toxicity, negatively affecting rice productivity. To address this issue, various adaptive cultivation technologies have been introduced, such as applying salicylic acid and selecting salinity-tolerant rice varieties.

Future rice production will face increasing challenges from biotic and abiotic stresses, including salinity. Among the adaptive strategies, cultivating salinity-tolerant varieties remains the most economical and effective solution. As saline-affected land continues to grow, efficient strategies for integrating plant adaptability with environmental conditions become increasingly critical. Globally, more than 800 million hectares of agricultural land are estimated to be impacted by salinity. In Indonesia, over 20% of agricultural land is believed to have become saline due to global climate change, potentially reaching one million hectares.

Saline soil is a persistent issue, particularly in rice cultivation. High salinity induces ion toxicity, which diminishes rice yields. Salicylic acid (SA) serves as a signaling molecule that mitigates the adverse effects of abiotic stress, including drought, and plays a vital role in regulating plant growth processes such as nitrate metabolism, photosynthesis, and ethylene production during flowering (Ningrum, 2021).

Jini and Joseph (2016) noted that SA application enhances growth and yield under salt stress while elucidating its physiological mechanisms for salt tolerance. SA contributes to plant growth regulation, flowering, fruit production, and germination. Its role in defense mechanisms under biotic and abiotic stress highlights its ability to alleviate salt stress through the modulation of antioxidant enzyme activity in plants.

Increased salinity in water and soil exposes plants to environmental stress. Saline conditions in rice fields often occur in coastal areas or fields directly connected to seawater (Sukarman et al., 1998; Rachman et al., 2018). During high tides, seawater infiltrates rice fields via irrigation channels, necessitating environmental management strategies like floating rice field systems.

The application of salicylic acid is expected to enhance growth and yield in Inpari 34 Salin and Batang Piaman varieties, particularly in saline soils of Riau. Based on these considerations, the study was conducted to evaluate the effects of salicylic acid on the growth and resilience of two rice varieties (*Oryza sativa* L.) in saline soil using a floating rice paddy system.

The study aimed to analyze the interaction effects of salicylic acid and two rice varieties on the growth and yield of rice plants (*Oryza sativa* L.) in saline soils with a floating rice field system. Additionally, it sought to determine the individual effects of salicylic acid and different rice varieties on growth and yield under the same conditions.

2. Research Methods

2.1 Time and Place

The research was carried out in the greenhouse of the experimental garden at the Faculty of Agriculture, Islamic University of Riau, located on Jalan Kaharuddin Nasution Km. 11, No. 113, Air Dingin Village, Bukit Raya District, Pekanbaru City. The study lasted for five months, from February to June 2024 (Appendix 1).

2.2 *Materials and tools*

The materials used in this study included rice seeds of the Inpari 34 Salin Agritan and Batang Piaman varieties (Appendix 2), salicylic acid, NaCl salt, Dithane M-45, furadan, and raffia rope. The tools utilized were seeding containers, tarpaulin (measuring 2 x 2.5 x 0.5 meters), wooden blocks, a pH meter, styrofoam, chlorophyll meter, binocular microscope, measuring cup, ruler, camera, digital thermometer, analytical scales, and stationery.

2.3 Experimental Design

The study employed a Completely Randomized Design (CRD) with a factorial arrangement comprising two factors. The first factor was salicylic acid, with 4 levels, and the second factor was rice varieties, with 2 levels, resulting in 8 treatment combinations. Each treatment combination was replicated 3 times, yielding a total of 24 experimental units. Each replication included 4 plants, with 2 plants used as samples, bringing the total number of plants to 96.
The treatment is as follows:
The concentration factor of Salicylic Acid (A) consists of 4 treatment levels:
A0 = 0 mg salicylic acid treatment
A1 = 30 mg salicylic acid /l water
A2 = 60 mg salicylic acid /l water
A3 = 90 mg salicylic acid /l water

Factor (F) consists of 2 treatment levels:
F1 = Inpari 34 Salin
F2 = Batang Piaman

From the two factors above, a combination of treatments is obtained as in Table 1 below.

Table 1. Combination of Salicylic Acid and Varieties in Lowland Rice Plants

Variety (F)	Treatment Salicylic Acid (A)			
	A0	A1	A2	A3
F1	F1A0	F1A1	F1A2	F1A3
F2	F2A0	F2A1	F2A2	F2A3

The data from the final observations of each treatment were analyzed statistically. If the calculated F-value exceeded the F-table value, the analysis was followed by an Honest Significant Difference (HSD) test at the 5% significance level.

2.4 Research Implementation

2.4.1 Making Tarpaulin Pools

Prior to conducting the research, the initial step involved preparing the pond using a tarpaulin supported by a wooden frame with dimensions of 4 x 2.5 x 0.5 meters. The tarpaulin was first cleaned by washing it. After assembling the frame into a rectangular shape and covering it with the tarpaulin, the pond was filled with water to a depth of 30 cm.

2.4.2 Preparation of research materials

1. Seed preparation

Prior to sowing, the rice seeds were soaked for 24 hours in water containing a fungicide. The fungicide used was Dithane M-45 at a concentration of 3 ml/L of water. The varieties utilized were Inpari 34 Salin Agritan and Batang Piaman, with the seeds sown in a 22 oz (660 ml) cup filled with soil and labeled according to the experimental plan (Appendix 3). Three seeds were sown per cup. At seven days after planting, the seedlings were transferred to the prepared pond, maintaining a spacing of 25 cm x 25 cm between the cups.

2. Planting

Three seeds were planted in each cup, which was then placed in a pond supported by a styrofoam platform. The cups were arranged with a spacing of 25 cm x 25 cm between them.

3. *Preparation of saline water (NaCl).*

The NaCl mixture process began by filling the water tarpaulin pool with 3 m^3 (3000 L) of water. Then, 21 kg of NaCl (7000 ppm) was added and thoroughly mixed to ensure even distribution.

2.4.3 Salicylic acid treatment

Salicylic acid was applied three times during the study, with a 10-day interval between each application. The first application was made when the rice plants were 21 days old (DAP), the second at 31 days old (DAP), and the third at 41 days old (DAP). The treatment concentrations were 0, 30, 60, and 90 mg/L of salicylic acid in water. To prepare the solution, salicylic acid was dissolved in 1 liter of water, then mixed with 2 ml of Agristick adhesive. The solution was sprayed onto the leaf surface at 08:00 AM, with 1 liter of the salicylic acid solution applied per experimental unit, or 250 ml per plant.

2.4.4 Application of basic fertilizer

The base fertilizer was applied one week before planting using NPK Mutiara 16:16:16 at a dosage of 11.25 g per plant (Yosri, 2020). The fertilizer was evenly spread over the cup and then mixed thoroughly with the soil.

2.4.5 Maintenance

Analysis of chemical characteristics of water

1. Salinity Level (ppm)
   Salinity measurements were conducted to ensure optimal plant growth, targeting a level of 7000 ppm. If the salinity dropped below 7000 ppm, NaCl salt was added. The pond water was checked daily, and adjustments were made if the water level decreased.
2. Degree of Acidity (pH)
   pH measurements were taken to ensure optimal plant growth, with a target pH of 8.5. If the pH fell below 8.5, KOH was added to raise it to the desired level. Pond water was checked daily, and adjustments were made if the water level decreased.

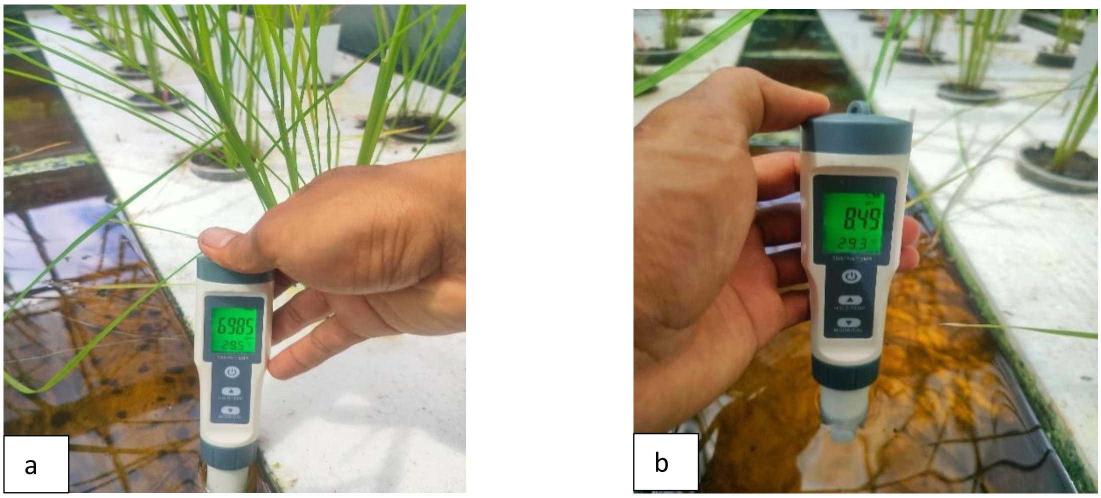

Figure 2.1 (a) salinity level in pond water, (b) pH conditions in pond water

3. Pest and disease control.
   Pest and disease control is done preventively. For preventive control, it is done by cleaning the pond before use and cleaning the area around the research.

2.4.6 Harvest

Rice harvesting is done when the plants meet the criteria, including 90% of the flag leaves and grain leaves turning yellow, or when the panicle droops due to the weight of the rice grains. Additionally, harvesting is determined by pressing the rice; if it feels firm, it is ready to be harvested. The rice is harvested by cutting the base of the rice panicle with scissors.

3.1. Observation Parameters

1. Plant Height (cm)
   Plant height observations were conducted when the plants were 14 to 70 days old. The plant height was measured from the base of the stem to the tip of the longest leaf, using a meter. The data obtained were analyzed statistically, presented in tables, and periodically displayed in the form of graphs.
2. Flowering Age (days)
   Observation of the flowering age of rice plants was carried out from the time the rice seeds were planted until the first flower appeared on each sample in the experimental unit plot. The observation data were analyzed statistically and presented in tabular form.
3. Number of Stomata (fruit)
   Counting the number of stomata was done by applying transparent clear nail polish on rice leaves measuring 1 × 1 cm, allowing it to dry. After drying, the nail polish was removed with tape and placed on a slide. The slide was then observed under a binocular microscope with 40x magnification. Observations were made when the plants were 42 days old. The observation data were analyzed statistically and presented in tabular form.
4. Chlorophyll content (μ mole)
   Observation of leaf chlorophyll content was carried out by calculating the number of days from when the rice seeds were planted until the rice reached the harvest criteria at 70 days after planting (DAP). This observation was conducted before 12:00 PM during sunny weather under direct sunlight or in conditions without shade, by clamping the leaves using a chlorophyll meter on the 6th and 7th leaves. The data obtained from the observations were analyzed statistically and presented in tabular form.
5. Number of Saplings Per Clump (stem)
   Observation of the number of tillers per clump of rice was carried out at 42 days after planting by counting the total number of tillers in each clump of rice plants used as samples. The observation data were analyzed statistically and presented in tabular form.
6. Harvest Age (days)
   Observation of the harvest age of rice plants is carried out by calculating the number of days from when the rice seeds are planted until the rice meets the harvest criteria in each sample within the experimental unit plot. The observation data are analyzed statistically and presented in table form.
7. Panicle length (cm)
   Observation of panicle length per sample after harvest was carried out by measuring from the base to the tip of the panicle on the experimental unit sample plants. The observation data were analyzed statistically and presented in tabular form.
8. Grain Weight Per Clump (g)
   Observation of grain per clump per sample was conducted by air-drying the grains for 5 days at the end of the study. The observation involved weighing the weight of the ready-to-mill grain

from the experimental unit sample plants. The observation data were analyzed statistically and presented in tabular form.

9. Root Volume (cm^3)
   Observation of root volume is carried out by cleaning the roots and separating them from the crown. The roots are then placed into a 100 ml measuring cup containing 50 ml of water. The root volume is determined by the increase in water volume from the original level. Data from these observations are recorded at harvest time and presented in tabular form. The formula used is as follows:

$$\text{Root Volume} = \text{Final Water Volume} - \text{Initial Water Volume}$$

3. Results and Discussion

3.1 Plant Height (cm)

Based on the results of observations on the height of rice plants and the analysis of variance, it shows that both the interaction and main effects of salicylic acid and the two varieties of rice plants on saline soil with a floating rice field system did not have a significant effect on plant height. The average results of the observations on the height of rice plants in lowland rice fields can be seen in Table 2.

Table 2. Height of rice plants after being given salicylic acid to two varieties (cm)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	84.03	83.85	78.70	82.41	82.25
Batang Piaman (F2)	83.38	86.30	84.60	80.50	83.69
Average	83.70	85.07	81.65	81.45	
KK = 7.07%					

The numbers in the columns followed by the same lower case letter are not significantly different according to the BNJ honest significant difference test at the 5% level

Data in Table 2 below show that the highest plant height obtained from the study was 86.30 cm. However, in the description, the plant height is recorded to be between 105 and 117 cm. This indicates that the study recorded a lower plant height than expected, which can be attributed to environmental factors. According to Raja (2016), the use of different varieties leads to varying potential results, contributing to genetic diversity.

Environmental factors, such as the salt content in saline soil, can significantly affect the height of rice plants, as they are linked to the plant's mechanisms for salinity tolerance. These mechanisms may include the increase of antioxidant compounds or compatible solutes to enhance salinity tolerance. During the nursery phase, rising salinity levels greatly hinder vegetative growth, causing leaf abnormalities such as necrosis at the leaf tips and changes in leaf color (Purwaningrahayu, 2016).

Salinity stress interferes with growth, including the height of rice plants, as stressed plant cells expend more energy on metabolism. According to Barus et al. (2019), excessive salt in the root zone reduces a plant's ability to absorb water, leading to potential poisoning. Lisdyayanti et al. (2019) also noted that high salt content in the soil negatively impacts rice plant growth and production, leading to stunted height growth and chlorotic leaf sections. Although rice plants are classified as moderately tolerant to salinity, environmental stress still affects their growth, as shown in the height growth observed during the study, depicted in Figure 3.1.

Based on Figure 1, it is observed that plant height increased from 14 to 70 days. However, the plant height growth was not optimal, as compared to the standard height described in the author's research, which showed lower plant heights. This discrepancy can be attributed to both environmental and genetic factors, as discussed by Krisnawati and Adie (2009) and Kusmiyati et al.

(2014). In general, physiological and morphological traits of plants are primarily responsible for their response to salinity.

Salinity affects plant growth through four mechanisms: (1) high salt levels induce oxidative stress and lead to cell death, (2) osmotic stress caused by high salt levels, (3) high salt concentrations interfere with the absorption of K+, a vital nutrient for plants, and (4) elevated Na+ levels are toxic to cytosolic enzymes (Krisnawati and Adie, 2009; Cabot et al., 2014).

The rice varieties used in the study, Inpari 34 Salin Agritan and Batang Piaman, are both considered resistant to salinity. As such, treatment with salicylic acid may not have provided significant improvement in plant growth under optimal environmental conditions for rice (Hashempour et al., 2018).

The application of salicylic acid showed a significant stimulatory effect on plant height growth. However, the effects of chemicals or hormones can vary depending on their concentration and environmental conditions (Khan & Khan, 2014). In this case, the genetic resistance of the varieties to salinity may have been sufficient, meaning that additional treatment with salicylic acid did not offer further benefits in terms of plant height growth (Iqbal et al., 2014).

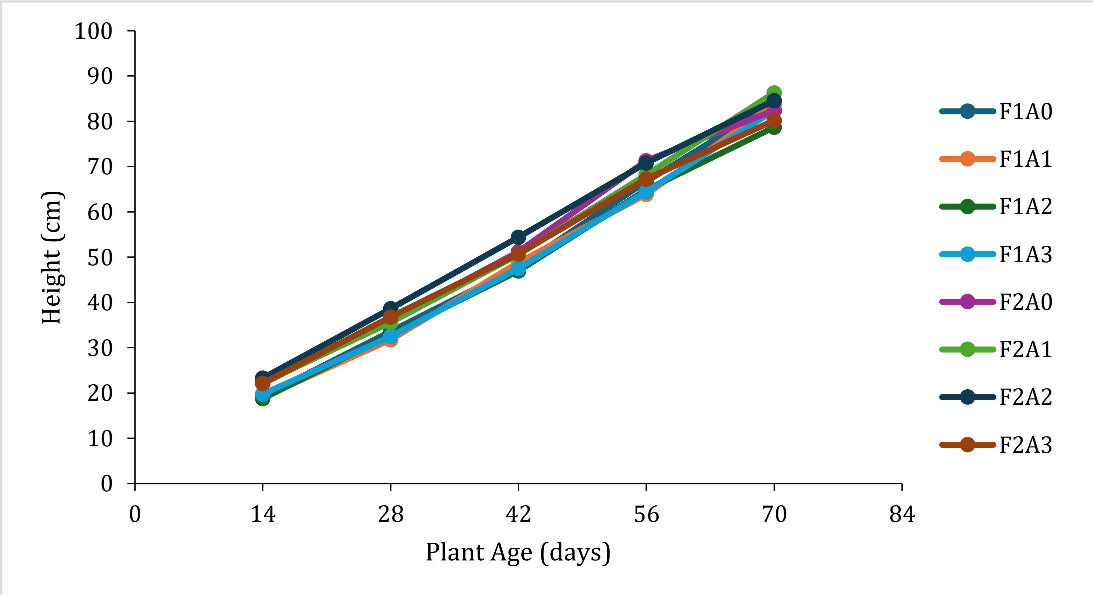

Figure 1. Graph of the growth of paddy plants aged 14, 28, 42, 56 and 70 days with the administration of salicylic acid and paddy varieties with a floating paddy system.

3.2 Flowering age (days)

Based on the results of observations on the flowering age of rice plants, after conducting an analysis of variance, it was found that the interaction between salicylic acid and the two varieties of rice plants in saline soil with a floating rice field system did not have a significant effect. However, the two varieties of rice showed a significant effect on the flowering age of the plants. Further analysis using the Honestly Significant Difference (HSD) test at the 5% level confirmed these findings. The results of these observations are presented in Table 3.

The data in Table 3 indicate that the two main rice varieties have a significant effect on the flowering age. The Inpari 34 Salin Agritan variety (F1) produces the fastest flowering age, at 85.50 HST, which is significantly different from the Batang Piaman variety (F2). On the other hand, the Batang Piaman variety (F2) has the longest flowering age, with an average of 89.83 HST. This delay in flowering is likely caused by salinity stress conditions.

Table 3 Flowering age of rice plants after being given salicylic acid to two varieties (day)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	85.66	86.66	84.75	84.91	85.50 a
Batang Piaman (F2)	89.83	90.08	89.91	89.50	89.83 b
Average	87.75	88.37	87.33	87.20	
KK = 2.31% BNJ F = 1.76					

The numbers in the columns followed by the same lower case letter are not significantly different according to the BNJ honest significant difference test at the 5% level

The Inpari 34 Salin Agritan variety demonstrates good resistance to saline soil, aligning with the findings of Indrayati et al. (2011), who recommended the use of saline-tolerant rice varieties to increase rice production in tidal swamp lands. The flowering phase is particularly sensitive to salinity stress, and genetic factors can influence this process (Park et al., 2016). Amirjani (2010) observed that IR-64 rice plants, under NaCl stress conditions, experienced a delay in flowering by 11 to 19 days due to osmotic stress during the vegetative phase, which impacted the generative phase.

The Inpari 34 Salin Agritan variety is genetically designed to have better resistance to environmental stresses, including salinity. This resistance can help accelerate physiological processes like flowering, which may explain why it flowers earlier than the Batang Piaman variety. This may involve more efficient hormone regulation mechanisms under salinity conditions, promoting earlier flowering (Ali et al., 2007).

Salicylic acid is known for its role in plant stress responses and defense, rather than directly regulating flowering. In this study, the main effect of salicylic acid may not have been strong enough to significantly affect flowering time compared to the varietal differences (El-Tayeb, 2005).

3.3 Number of stomata (fruit)

The results of the observations of the number of stomata in rice plants, after conducting an analysis of variance, indicate that the interaction of salicylic acid and the two rice varieties on saline soil with a floating rice field system does not have a significant effect. However, the main treatment of salicylic acid has a significant effect on the number of stomata in rice plants. The average results of these observations, after further Honestly Significant Difference (HSD) tests at the 5% level, are shown in Table 4.

Table 4. Number of stomata in rice plants after salicylic acid was applied to two varieties

Variety (F)	Asam Salicylate (mg/L air)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	116.66	139.00	136.00	147.00	134.66
Batang Piaman (F2)	121.33	124.00	136.66	157.00	134.75
Average	119.00b	131,50b	136,33ab	152.00 a	
KK = 8.27% BNJ A = 18.40					

The numbers in the columns followed by the same lower case letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

The data in Table 4 shows that salicylic acid has a significant effect on the number of stomata. Specifically, salicylic acid at a concentration of 90 (A3) resulted in an average of 152.00 stomata, which was not significantly different from the treatment with 60 (A2) but significantly different from the other treatments. The smallest number of stomata was found in the control group (A0), with an average of 119.00 stomata. This finding is supported by Wardana's research (2019), which suggests that the application of salicylic acid can modulate the uptake of key nutrients, enhancing the growth and development of rice plants.

Rice plants responded well to the administration of different salicylic acid concentrations, making the plants more resistant to salinity stress. According to Barus et al. (2021), salicylic acid plays a role in regulating physiological processes and providing protection against both abiotic and biotic stresses. One of its direct physiological impacts is the modulation of antioxidant enzyme activity, which increases plant tolerance to salinity stress.

Salicylic acid also plays a critical role in plant responses to stress, including salinity, by modulating stomatal activity. It can affect stomatal opening and closing, as well as stomatal density, which are crucial for regulating gas exchange and managing water loss. Under stress conditions, such as salinity, plants increase the production of salicylic acid as part of their defense mechanism. This increase can result in changes in the number and function of stomata, helping plants better manage environmental stress (Hayat et al., 2010).

Although plant varieties have genetic differences that affect various growth and development aspects, the number of stomata may be more influenced by environmental factors and hormonal treatments such as salicylic acid than by genetic differences between varieties (Rivas-San & Plasencia, 2011).

3.4 Chlorophyll content (µ mole)

Based on the results of observations of the chlorophyll content of rice plants, after conducting an analysis of variance, it was found that the interaction between salicylic acid and the two varieties of rice plants on saline soil with a floating rice field system did not have a significant effect. However, the main effect of the salicylic acid treatment did show a significant impact on the chlorophyll content of the rice plants. The average results of these observations, after further testing using Honestly Significant Differences (HSD) at the 5% level, can be seen in Table 5.

Table 5 Chlorophyll content of rice plants after being given salicylic acid to two varieties (µ mole)

Variety (F)	Asam Salicylate (mg/L air)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	30.50	30.83	30.05	32.83	31.05
Batang Piaman (F2)	30.47	30.35	33,13	34.26	32.05
Average	30.48 b	30.59 b	31.59 ab	33.55 a	
KK = 6.07% BNJ A = 3.16					

The numbers in the columns followed by the same lowercase letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

The data in Table 5 shows that salicylic acid significantly affects the chlorophyll content of rice plants, where a concentration of 90 mg/L salicylic acid (A3) results in a chlorophyll content of 33.55 µmol/m^3, which is not significantly different from the 60 mg/L salicylic acid treatment (A2) but significantly different from other treatments. The lowest chlorophyll content was found in the control (A0), with an average of 30.48 µmol/m^3.

This indicates that the application of salicylic acid at a concentration of 90 mg/L increases the chlorophyll content in rice plants. The positive effects of salicylic acid include enhanced photosynthesis, CO_2 assimilation, and mineral absorption by the plants. Salicylic acid can increase pigment content, thereby improving photosynthesis (Vazirimehr and Rigi, 2014). Chlorophyll, as part of the photosynthetic antenna, collects light, which is then transferred to the reaction center (Kusmiyati et al., 2014).

Salinity stress typically causes chlorosis, and high salt levels in the soil can damage chloroplast ultrastructure, reducing chlorophyll content, which negatively impacts plant production (Xing et al., 2013; Nokandeh et al., 2015). However, salicylic acid plays a crucial role in enhancing chlorophyll content by increasing the activity of enzymes involved in chlorophyll biosynthesis and maintaining chloroplast stability, such as δ-Aminolevulinic Acid Dehydratase (ALAD), Protochlorophyllide Reductase, Magnesium Chelatase, NADPH oxidoreductase (POR), and Chlorophyll Synthase. This promotes photosynthetic efficiency and plant resistance to environmental stresses like salinity (Khan & Khan, 2014; Nazar et al., 2011).

The two rice varieties used in this study, Inpari 34 Salin Agritan and Batang Piaman, did not have a significant effect on chlorophyll content. This may be due to the genetic differences between these varieties being small enough that they did not significantly influence chlorophyll levels under saline conditions. Since both varieties are resistant to salinity, the primary effect on chlorophyll content is more influenced by the salicylic acid treatment than by the variety factor.

3.5 Number of tillers per clump (stem)

The results of observations of the number of tillers per clump in paddy fields, after conducting an analysis of variance, show that while the interaction of salicylic acid and the two rice varieties on saline soil with a floating rice field system does not have a significant effect, both the main salicylic acid treatment and the two varieties do have a significant effect on the number of tillers. The average results of these observations, after further Honestly Significant Difference (HSD) testing at the 5% level, can be seen in Table 6.

Table 6. Number of tillers per clump of rice plants after salicylic acid was applied to two varieties (stems)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	8.00	8.50	10.00	9.16	8.91 a
Batang Piaman (F2)	7.66	7.50	8.66	8.33	8.04 b
Average	7.83 b	8,00 b	9.33 a	8.75 ab	
KK = 8,42% BNJ F = 0,61 BNJ A= 1,81					

The numbers in the column followed by the same lowercase letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

The data in Table 6 shows that salicylic acid significantly affects the number of tillers, with the 60 mg/L salicylic acid treatment (A2) producing an average of 9.33 tillers per clump, which is not significantly different from the 90 mg/L salicylic acid treatment (A3), but significantly different from other treatments. The smallest number of tillers per clump was found in the control (A0), with an average of 7.83 tillers. This indicates that the application of salicylic acid positively affects the number of rice tillers.

Joseph (2016) reported that salicylic acid can increase growth and yield under salt stress conditions and plays a crucial role in regulating plant growth, development, seed germination, flowering, and fruit yield. Salicylic acid induces various physiological responses in plants, including the enhancement of plant hormones such as auxin and cytokinin, which are involved in shoot formation and cell division, leading to an increased number of tillers. Moreover, salicylic acid also helps plants resist environmental stress, improving their vegetative growth (Khan & Khan, 2014).

The Inpari 34 Salin Agritan variety shows an average of 8.91 tillers, indicating its resistance to saline soil conditions. Inpari 34 Salin Agritan is known for producing a higher number of tillers and productive tillers compared to other varieties (Saidi et al., 2020). Varieties like Inpari 34 and Batang Piaman, which have distinct genetic characteristics, exhibit different abilities in producing tillers. For instance, Inpari 34 Salin Agritan may have a higher genetic potential to produce tillers than Batang Piaman. However, the lack of significant interaction between salicylic acid and varieties suggests that both factors may independently influence tiller production, without a strong synergistic effect (Arfan et al., 2007).

Husna (2010) noted that several factors, including mineral nutrients, solar radiation, planting distance, and cultivation practices, affect the number of tillers. Close planting distances may lead to competition for light and nutrients, affecting tiller growth. Genetic factors also play a significant role in determining the number of productive tillers. Muharam and Saefudin (2016) emphasized that plant components are influenced by the interaction of variety and saline land, with salinity stress becoming more evident during transplanting, young seedling, and flowering stages.

3.6 Harvest Age (days)

The data in Table 6 shows that salicylic acid significantly affects the harvest age of rice plants. The salicylic acid treatments caused differences in the harvest age, but the interaction between salicylic acid and the two varieties of rice plants did not significantly affect the harvest age. The salicylic acid treatment has a clear effect on when the rice plants are harvested, suggesting that the application of salicylic acid may help in adjusting the timing of harvest. Further testing using Honestly Significant Differences (HSD) at the 5% level can provide a more detailed analysis of these results.

Table 7. Harvest age of rice plants after being given salicylic acid on two varieties (days)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	123.80	121.50	120.91	120.66	121.54a
Batang Piaman (F2)	123.20	123.16	122.83	123.75	123.31b
Average	123.29	122.33	121.87	122.20	
KK = 1.08% BNJ F = 1.14					

The numbers in the columns followed by the same lowercase letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

The data in Table 7 shows that the variety of rice significantly affects the harvest age, with the Inpari 34 Saline variety (F1) having the earliest harvest at 121.54 days, which is significantly different from other treatments. The Batang Piaman variety (F2) has the latest harvest at 123.31 days. This difference in harvest age is primarily due to genetic factors of the rice varieties, as well as potential environmental factors like salinity stress.

The choice of variety plays a crucial role in optimizing the use of saline land, especially in areas affected by salinity stress due to climate change, which affects rice production, particularly during the dry season when irrigation water is limited. Rice plants can help alleviate salinity by washing salt from the surface of the soil to deeper layers, creating a more suitable environment for growth.

Studies by Abdullah and Tatit (2022) and others indicate that rice varieties vary in their ability to tolerate different soil and climate conditions, and specific varieties, such as those from the Agricultural Research and Development Agency (Balitbangtan), have been bred for salinity tolerance. These include Inpari Unsoed 79 Agritan, Inpari 34 Salin Agritan, and others.

Salinity stress can present challenges for rice cultivation, such as low availability of essential nutrients (N, P, and K), low osmotic pressure, high soil pH, and increased Na^+ content, all of which affect plant growth and productivity. The differences in harvest time among rice varieties are largely influenced by genetic factors, with each variety having its own growth cycle and time to reach physiological maturity (Guan et al., 2012; Zhou & Yang, 2015).

While salicylic acid plays a significant role in enhancing plant stress responses and improving overall plant health, it does not directly influence the harvest time. Instead, its effects are more related to improving stress resistance and photosynthetic efficiency, which ultimately impacts productivity but not harvest age. The lack of significant interaction between salicylic acid and rice varieties on harvest age suggests that the genetic factors of the varieties are more influential in determining the time of harvest, with salicylic acid primarily supporting plant growth under stress conditions (Khan & Khan, 2014).

3.7 Panicle Length (cm)

Based on the results of observations of the panicle length in paddy fields after conducting analysis of variance, it was shown that the interaction between salicylic acid and the two rice varieties on saline soil with a floating rice field system did not have a significant effect. However, the main variety factor did have a significant effect on the length of the rice plant panicles. The average results of panicle length observations after further testing of Honestly Significant Difference (HSD) at the 5% level can be seen in Table 8.

Table 8. Length of rice plant panicles after being given salicylic acid to two varieties (cm)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	15.60	15.13	14.05	15.51	15.07 b
Batang Piaman (F2)	18.10	18.06	19.93	19.21	18.82 a
Average	16.85	16.60	16.99	17.36	
KK = 9.28% BNJ F = 1.36					

The numbers in the columns followed by the same lowercase letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

The data in Table 8 shows that the main variety has a significant effect on the length of the panicle. The Batang Piaman variety (F2) produces an average panicle length of 18.82 cm, which is significantly different from other treatments. Meanwhile, the shortest panicle length is found in the Inpari 34 saline variety (F1), with an average length of 15.07 cm. This indicates that the difference in panicle length is influenced by both genetic and environmental factors. The ability of plants to adapt and utilize environmental factors affects their photosynthesis activity, which in turn impacts growth and productivity, including panicle and grain formation.

According to Atman (2005), one of the factors contributing to the increased grain yield of the Batang Piaman variety is the improvement of yield components, including panicle length, number of grains per panicle, and number of full grains per panicle.

Panicle length is an important morphological trait influenced by the genetic potential of the variety. Each rice variety has different genetic potential for panicle size and length, which depends on the plant's ability to develop spikelets and panicle branches. Some rice varieties may be bred to have longer panicles, directly impacting yield (Yuan & Chen, 2013).

While salicylic acid helps to increase stress resistance and photosynthetic efficiency, it does not directly affect panicle length. Salicylic acid primarily influences physiological aspects such as vegetative growth and response to environmental stress, rather than morphological traits like panicle length. Additionally, the interaction between salicylic acid and varieties may not show a significant effect, as the impact of each factor may not be sufficient to alter panicle length, which is largely influenced by genetic characteristics. Thus, panicle length is more influenced by the genetic differences between varieties than by salicylic acid treatment or the interaction of the two factors (Munns & Tester, 2008).

3.8 Grain Weight Per Clump (g)

The data in Table 9 shows that both the interaction and main effects of salicylic acid and the two varieties of rice plants on saline soil with a floating rice field system have a significant effect on the weight of grain per clump of paddy rice plants. The average results of these observations, after further testing for Honestly Significant Differences (HSD) at the 5% level, are presented in the table. This indicates that the application of salicylic acid, along with the specific rice varieties used, plays a substantial role in determining the weight of grains per clump, which is a key factor in overall rice yield.

The data in Table 9 shows that the interaction between the application of 60 mg/L salicylic acid (A2) and the Batang Piaman variety (F2A2) results in an average grain weight of 6.71 g, which is not significantly different from the F2A3 treatment but is significantly different from other treatments. Meanwhile, the lowest grain weight per clump was produced by the Inpari 34 saline variety, which aligns with the observation that this variety has the shortest panicle length.

The highest grain weight observed in the F2A2 salicylic acid treatment (6.71 g) suggests that salicylic acid may enhance grain production in the Batang Piaman variety, likely due to its tolerance to salinity stress. This finding is consistent with Atman's (2006) study, which reported that using Batang Piaman seeds aged 20 days after planting resulted in better yield components and grain yields, while planting at the wrong seed age could reduce yields by 5.97-13.50%

Table 9. Weight of grain per clump of rice plants after being given salicylic acid to two varieties (g)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	3.21 c	3.14 c	2.41 c	2.33 c	2.77 b
Batang Piaman (F2)	5.50 b	5.43 b	6.71 a	6.43 ab	6.01 a
Average	4.35	4.28	4.56	4.38	
KK = 8.10% BNJ F = 0.30 BNJ AF = 1.00					

The numbers in the columns followed by the same lowercase letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

This highlights the importance of increasing national rice production through the development of superior rice varieties with high yield potential (Las, et al., 2004). Rice plants that tolerate salinity during the reproductive phase can excrete salt from flag leaves and panicles. However, no local cultivars have been found to exhibit both vegetative and generative salinity tolerance. Rice tolerance to salinity at planting typically remains around 4 mmhoscm-1 (Jalil et al., 2016; Sodhiq, 2020).

Each rice variety has a different ability to collect and allocate nutrients and energy for grain formation, directly affecting grain weight. Salicylic acid contributes by enhancing photosynthetic efficiency, plant health, and stress resistance. It can also increase enzyme activity related to carbohydrate biosynthesis and secondary metabolism, which supports grain growth and filling (Hossain & Asaduzzaman, 2014; Khan & Khan, 2014).

The interaction between salicylic acid and rice varieties plays a significant role as both factors influence growth and seed formation. Salicylic acid can enhance the response of certain varieties to environmental conditions, thus affecting overall grain weight. The synergistic effect between salicylic acid treatment and genetic characteristics of rice varieties can optimize grain yield through a combination of physiological improvements and genetic potential (Hayat, et al., 2007).

3.9 Root Volume (cm ^{3})

Based on the results of observations of the root volume of rice plants after conducting analysis of variance, it was shown that the interaction and main effects of salicylic acid and two varieties of rice plants on saline soil with a floating rice field system have a significant impact on the root volume of rice plants. The average results of the root volume observations were further tested for Honestly Significant Differences (HSD) at the 5% level, and the results can be seen in Table 10.

Table 10. Volume of rice plant roots after being given salicylic acid to two varieties (cm3)

Variety (F)	Salicylic Acid (mg/L water)				Average
	0 (A0)	30 (A1)	60 (A2)	90 (A3)	
Inpari 34 Salin (F1)	8.66 d	9.83 d	12.16 cd	16.66 ab	11.83 b
Batang Piaman (F2)	11.33cd	15.33 c	17.33 ab	20.33 a	16.08 a
Average	10.00 c	12.58 c	14.74 ab	18.49 a	
KK = 1.08% BNJ A = 2.52 BNJ F= 1.32 BNJ AF = 4.31					

The numbers in the columns followed by the same lowercase letter are not significantly different according to the BNJ honest significant difference test at the 5% level.

The data in Table 10 shows that the interaction between the administration of salicylic acid 90 mg/L (A3) and the Batang Piaman variety (F2A3), which results in a root volume of 20.33 ml, is not significantly different from the F2A2 treatment but is significantly different from other treatments. The smallest root volume was found in F1A0 with an average root volume of 8.66 ml. This indicates that abiotic stress, in the form of salinity, significantly affects plant production quality. Salinity is known to influence stem growth, leaf area, and root development (Cabot et al., 2014; Kusmiyati et al., 2014). This stress results from imbalances in metabolism caused by ion toxicity, osmotic stress, and nutrient deficiencies. According to Muharam and Saefudin (2016), plant yield components are largely controlled by the interaction between varieties and soil salinity.

Root volume is a key indicator of a plant's ability to absorb water and nutrients and to adapt to its environment. The significant effect of variety on root volume can be explained by genetic differences that affect the plant's capacity for root growth. Different rice varieties exhibit varying root development, which influences how deep and expansive their root systems are. Varieties with wider and deeper root systems can access more water and nutrients, enhancing growth and overall productivity (Hossain & Asaduzzaman, 2014).

Salicylic acid, a compound involved in plant stress responses, can also affect root volume by improving the health and efficiency of the root system. It can stimulate the formation of lateral roots, enhance the activity of enzymes linked to root growth, and improve the structure and function of root tissues. Additionally, salicylic acid helps increase root resistance to stress conditions such as salinity, which is known to impact root growth (Hayat et al., 2007).

The interaction between salicylic acid and variety is influential because these two factors can interact to enhance root growth. For instance, varieties that are genetically predisposed to good root development can benefit from salicylic acid treatment, which further improves nutrient and water absorption. Similarly, salicylic acid can enhance the response of certain varieties to stress, thereby positively affecting overall root volume development. Therefore, the synergistic effect between salicylic acid treatment and genetic characteristics of varieties can significantly influence root volume (Khan & Khan, 2014).

4. Conclusions

Based on the results of this study it can be concluded that: The interaction between salicylic acid and the two rice varieties had a significant effect on grain weight and root volume, with the best treatment observed in the Batang Piaman variety combined with a salicylic acid concentration of 90 mg/L of water. The main effect of salicylic acid was significant on the number of stomata and chlorophyll content. The most effective treatment for these parameters was a salicylic acid concentration of 90 mg/L of water. The main effect of the two rice varieties was significant on panicle length, grain weight, and root volume, with the best results observed in the Batang Piaman variety.

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