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Evaluation of the Viability and Vigor of Karya Pelalawan Rice Seeds (*Oryza sativa* L.) Under Salt Stress Conditions

Mardiani Putri [1], Yudia Azmi[1], Salmiyati Salmiyati[1]

[1]Department of Agrotechnology, Institut Teknologi Perkebunan Pelalawan Indonesia, Pelalawan, Indonesia

*Correspondence E-mail: udiaazmi@gmail.com

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ABSTRACT

Background: One of the well-known rice varieties from Pelalawan is the Karya Pelalawan rice, which can be developed in tidal swamp lands in Riau Province. The tidal lands of Pelalawan Regency frequently experience variable salinity levels, yet the salinity tolerance of the Karya Pelalawan rice variety remains poorly defined. Consequently, it is necessary to conduct tests across diverse salinity concentrations.
Aims: This research aims to identify the tolerant concentration of NaCl in the salinity test on the viability and vigor of rice seeds (Oryza sativa L.) of the Karya Pelalawan variety.
Methods: The study employed a non-factorial Completely Randomized Design (CRD) consisting of 5 treatments with 5 replications. The treatments were as follows: P0 (0 ppm), P1 (2500 ppm), P2 (5000 ppm), P3 (7500 ppm), and P4 (10000 ppm). The observed parameters included germination percentage, first count test (FCT) percentage, germination rate, radicle and plumule growth of seedlings, and seed vigor test. Data were analyzed using Excel and ANOVA, followed by the DMRT at 5% significance level.
Results: The results showed that NaCl application affected the germination percentage, FCT percentage, germination rate, radicle and plumule growth, and seed vigor. The tolerant NaCl concentration for germination was P1 (2,500 ppm) as seen from the germination percentage, FCT percentage, germination rate, and seed vigor.
Conclusion: The application of salinity stress can affect germination characteristics. However, at 2500 ppm, it can improve the germination quality of Karya Pelalawan rice seeds.

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1. Introduction

Rice (*Oryza sativa* L.) is an annual crop with high adaptability to various environmental conditions. Nationally, Indonesia's rice production in 2022 reached approximately 54.75 million tons/kg, demonstrating this commodity's role as a primary national food source (Central Statistics Agency 2023). In Riau Province, by 2024, the rice harvest area is estimated at 57,000 hectares, with rice production of approximately 225,840 tons of dry milled grain (Central Statistics Agency 2024). Pelalawan Regency is the sixth-largest rice-producing regency in Riau Province, after Indragiri Hilir, Rokan Hilir, Kuantan Singingi, Siak, and Kampar. This makes Pelalawan Regency play a significant role in increasing rice production in Riau Province (Central Statistics Agency 2024). In the Kampar estuary region, two superior local rice varieties, Cekau Pelalawan and Karya Pelalawan, have been developed and officially recognized by the Indonesian Minister of Agriculture. The Karya Pelalawan variety has a yield of approximately 5.63 tons/ha, slightly lower than that of the Cekau Pelalawan variety, which yields 5.83 tons/ha. The potential for development of these varieties is supported by the availability of 640,693 hectares of tidal land in Riau (BBSDLP 2020).

One of the limiting factors for rice cultivation in tidal-prone areas is relatively high salinity, particularly during periods of seawater intrusion and tidal dynamics. Rice is particularly susceptible to saline environments (high salt levels), which can reduce productivity. Tidal swamps hold significant potential for rice development, but their utilization has not been optimal due to various technical and environmental constraints. One major obstacle is fluctuations in water levels, which often cause flooding during the rainy season and extreme dryness during the dry season. This water instability disrupts plant growth and causes significant physiological stress (Bisri *et al.,* 2026). Furthermore, the soil chemistry in tidal swamps is generally unfavorable, with low pH (acidic), high dissolved Fe and Al contents, and low availability of macronutrients. These conditions can lead to metal toxicity in rice plants and reduce nutrient uptake efficiency (Noor, 2004). The acid sulfate soil characteristics in some areas also pose a limitation because, upon oxidation, they produce strong acids that degrade soil fertility.

Salinity stress can suppress plant growth processes by inhibiting cell enlargement and division, protein production, and increasing plant biomass (Liu *et al.,* 2022). Salinity stress causes high salt levels in water and soil, resulting in abiotic stress for plants (Yusuf *et al.,* 2026). High salt concentrations, particularly NaCl, which is predominant in coastal areas and areas intruded by seawater, cause Na^+ and Cl^- ion toxicity, inhibit water absorption by roots, and affect osmotic and ionic mechanisms in plant cells (David *et al.,* 2021). This condition also impacts various plant physiological processes such as nutrient uptake, water transport, and growth (Kesmayanti & Romza, 2022). Previous research has been conducted by Kesmayanti & Romza (2022) with NaCl concentrations used consisting of 0 ppm (water), 2,500 ppm, 5,000 ppm, 7,500 ppm and 10,000 ppm with the results of the vigor test of rice seeds of the Inpari-22 and Mekongga varieties which are able to tolerate salinity with the higher concentration of NaCl, the higher the rate of decline.

Seed vigor is an indicator of physiological quality that shows the ability of seeds to grow normally in suboptimal conditions and is closely related to seed viability (Sari & Faisal, 2017). *However, until now still limitation research on salinity on the viability and vigor of rice seeds of the Karya Pelalawan variety, the purpose of this research is author is to test the viability and vigor of rice seeds Karya Pelalawan variety under salinity stress conditions*. This study was to determine and obtain a tolerant NaCl concentration for the viability and vigor of rice seeds (Oryza sativa L.) Karya Pelalawan variety.

2. Methods

2.1 Research Design

This research was conducted at the Agrotechnology Laboratory, Pelalawan Indonesian Institute of Technology, Pangkalan Kerinci District, Pelalawan Regency, from September to November 2024. The research used various tools such as planting tubs, measuring cups, petri dishes, analytical scales, spray bottles, rulers, cameras, and stationery. The materials used included Karya Pelalawan variety rice seeds, table salt (NaCl) as a treatment material, oil palm fronds, brown sugar, rice soaking water, a mixture of sand and soil in a 1: 1 ratio as a vigor test medium, Furadan 3G insecticide/nematicide, fungicide with active ingredient Mancozeb 80%, distilled water or sterile water, stencil paper as a viability test medium, label paper, thread, and seed base or container. This study used a Completely Randomized Design (CRD) with five levels of NaCl concentration treatment (0, 2500 ppm, 5000 ppm, 7500 ppm, and 10000 ppm) each repeated three times so that there were a total of fifteen experimental units in Table 1.

Table 1. NaCl treatment concentration

Treatment code	Treatment
P0	Control
P1	2500 ppm = 2500 mg/L
P2	5000 ppm = 5000 mg/L
P3	7500 ppm = 7500 mg/L
P4	10000 ppm = 10000 mg/L

2.1 Experimental Process

2.1.1 Collecting oil palm frondst

The oil palm fronds used in the production of local microorganisms (LMO) come from community plantations in Pangkalan Kerinci. The fronds are taken from eight-year-old, productive plants. One frond is used to produce LMO (Novrianti, 2021).

2.1.2 Making fermentation bottles

The LMO fermentation containers used are two 1.5 L mineral water bottles with modified caps. A hole is drilled into each cap to fit the hose used. The hose is inserted through the hole to connect the two bottles. The hose serves to channel the gas produced during the fermentation process (Supriatin *et al.*, 2025).

2.1.3 Making LOM from oil palm fronds

The harvested fronds were chopped into 1x1 cm cubes. 0.5 kg of oil palm fronds were chopped, then washed in a container of water and air-dried. Next, 150 g of brown sugar was diluted with 1 L of rice water. The 0.5 kg of fronds were placed in a bucket containing the rice water and brown sugar solution, then stirred until evenly distributed. Next, the LOM from the oil palm fronds was transferred to a 1.5 L mineral water bottle using a funnel, then filled with 1 L of water into the bottle connected to a hose (Figure 1). The fermentation process takes between 3-14 days and is characterized by an alcoholic aroma (the aroma of tapai). The finished LOM was filtered and transferred into a clean bottle, ready for use (Novrianti 2021).

Figure 1. Making LOM from oil palm fronds.

2.1.4 Preparation of rice seeds

Rice seeds are selected based on morphology, such as the color is yellow. Black or moldy seeds are discarded. The selected rice seeds are then soaked in oil palm frond LOM to determine whether the seeds are full or not. Full seeds will sink, while empty seeds will float or even float to the surface. The LOM dosage used for soaking rice seeds is 77 ml/L of water (Dewi, 2016). Then, the seeds are soaked in MOL for 16 hours (Azmi *et al.,* 2022).

2.1.5 Application of NaCl treatment

Rice seeds were soaked in NaCl treatment at the specified concentration for 48 hours in a baker's glass (Figure 2). The seeds were planted in planting trays according to the treatment: 0 ppm (water), 2,500 ppm, 5,000 ppm, 7,500 ppm, and 10,000 ppm. The NaCl stress treatment was continued by spraying the media (stencil paper and soil) until wet twice daily with the NaCl solution until the plants were 14 days old (Kesmayanti & Romza, 2022). Watering was carried out with distilled water using a sprayer, spraying 3-4 times daily.

Figure 2. Soaking rice seeds using NaCl

2.1.6 Handling of seed germination

Rice seeds soaked in NaCl were germinated on 21.5 x 32.5 cm stencil paper. Three sheets of stencil paper were used: two as a base and one as a moistened cover. The germinated seeds were watered twice daily. This stage included germination tests, first count tests, germination rate tests, and root and stem growth tests.

2.1.6.1 Germination Process

The germination test aims to determine the germination capacity of each lot of plant seeds, which reflects their viability. The first step is to prepare 250 rice seeds for each treatment. Then, the seeds are placed in bottles filled with LOM for 16 hours. Next, the seeds are soaked in NaCl for 48 hours with the predetermined treatment (Figure 2). Next, prepare damp stencil paper (wetted with water). 50 rice seeds are germinated in each replication. The seeds are arranged in 5 rows and 10 rows, then rolled. The final step is to place the rolled stencil on a tray as a germination tray (Azmi *et al.,* 2022). Data obtained from this process will be used to analyze the first count test, percentage of germination power (%), germination rate (days).

2.1.6.2 Radicle and plumule growth test process

A total of 75 seeds were germinated for each treatment. The seeds were then placed in bottles filled with LOM for 16 hours. The seeds were then soaked in NaCl for 48 hours with the prescribed treatment. Next, prepare damp stencil paper (wetted with water). Fifteen rice seeds were germinated in each replication. The seeds were arranged in an orderly manner in 3 rows and 5 rows, then rolled. The final step was to place the stencil roll at an angle on the germinator (Azmi *et al.,* 2022).

2.1.6.3 Vigor test (%)

The purpose of seed vigor testing was to conduct a soil emergence test. Twenty-one rice seeds were used for each treatment. The seeds were then placed in bottles filled with LOM for 16 hours. Subsequently, the seeds were soaked in NaCl with the prescribed treatment. 50 rice seeds were germinated per replication. The seeds were arranged in 5 rows and 10 rows in trays filled with soil and sand in a 1:1 ratio (Azmi *et al.,* 2022) (Figure 3). Maintenance was carried out by watering using a spray bottle, as well as controlling pests using Furadan 3G and fungicides when needed.

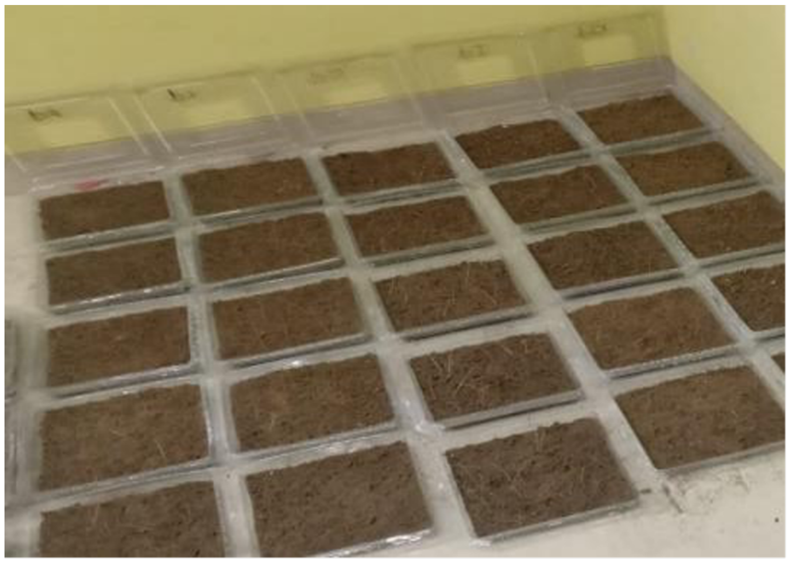

Figure 3. Rice Seed Vigor Test

2.1.7 Observation parameters

2.1.7.1 First Count Test

The first count test aims to determine seed germination strength and germination rate by measuring the seed germination rate on the first day of observation. The first count test is performed only once, on the fifth day after seed germination (International Seed Testing Association, 2013; Azmi *et al.,* 2022). Germination on the first count can be calculated using the following formula:

$$FCT\ (\%) = \frac{\sum \text{Number of normal seedlings on the 5th day}}{\sum Total\ number\ of\ seeds\ tested}\ x\ 100 \quad (1)$$

2.1.7.2 Germination power percentage

The first observation was made on the 5th day after the seeds germinated until the 14th day after germination. The germination percentage can be calculated using the following formula:

$$Germination\ Power\ (\%) = \frac{\sum \text{Number of normal seedlings on the 5th}-\text{14 th day}}{\sum Total\ number\ of\ seeds\ tested}\ x\ 100 \quad (2)$$

2.1.7.3 Germination rate

This germination rate test (Germination Speed Index) aims to determine seed germination strength and vigor. Observations are conducted one day after seed germination until the 14th day, or until no more seeds germinate (Azmi *et al.,* 2022). Seed germination rate can be calculated using the following formula:

$$\mathrm{GSI} = \sum_{i=1}^{n} \frac{N_i}{T_i}$$

N_i = number of normal seedlings germinated on the i-th day
T_i= observation time (days after sowing)
N = total number of observation periods (or total number of counting days)

2.1.7.4 Growth of radicle and plumule of sprouts

Observations were conducted on day 14 because at this stage, seedling growth has entered a stable early developmental stage, allowing the radicle and plumule to develop sufficiently to provide more accurate data on seed response to salinity treatment. Day 14 is considered the ideal time to assess continued seedling growth, particularly for radicle and plumule length, as tissue differentiation is more pronounced at this stage and growth is no longer significantly affected by initial germination variations. Furthermore, measuring seedling length on day 14 allows for further evaluation of seed vigor and growth capacity under stress conditions. Measurements were made using a thread that followed the length of the radicle and plumule, then measured with a ruler to obtain precise length data (Azmi *et al.,* 2022). This radicle and plumule growth test aims to determine seedling growth rate by measuring the length of the radicle and plumule from the root tip to the root collar (Parnidi *et al.,* 2022). Stem length was measured from the root collar to the leaf tip, as shown in Figure 4:

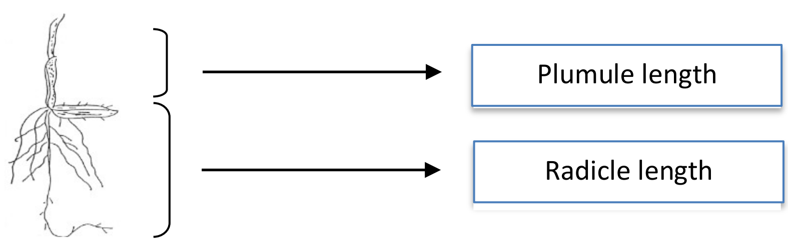

Figure 4. Measurement of plumule and radicle.

2.1.7.5 *Seed Vigor Test*

Observations were made on the 7th day, with the criteria being strong and weak/dead sprouts. Seed vigor testing can be calculated using the following formula:

$$\text{Seed Vigor Test (\%)} = \frac{\sum \text{Seeds that germinate normally}}{\sum \text{total number of seeds germinated}} \times 100$$

2.2 Data analysis

Based on the observation parameters of the germination test, the first count test, germination speed, and vigor test were analyzed quantitatively. Data obtained from the observations were analyzed using Excel software to find the average (Elita *et al.,* 2023). Plumule and radicle growth test data were analyzed using Analysis of Variance (ANOVA), the results of the analysis of variance were then tested for F to determine the level of difference in each treatment, if the calculated F is greater than the F table, then continued with the Duncan Multiple Range Test (DMRT) at the 5% level (Junaidi *et al.,* 2019).

3. Results and Discussion

3.1 First Count Test

The First Count Test (FCT) for seed germination is a test of seed germination strength, speed, and uniformity. Based on the results of the FCT test, the FCT percentage (%) for Karya Pelalawan rice seeds is shown in Table 2.

Table 2. First Count Test on Karya Pelalawan variety rice seeds.

Treatment	Percentage (%)
P0	3.0
P1	5.0
P2	4.5
P3	2.0
P4	0.5

Description: P0 (Concentration 0 ppm), P1 (Concentration 2,500 ppm), P2 (Concentration 5,000 ppm), P3 (Concentration 7,500 ppm), P4 (Concentration 10,000 ppm).

Based on Table 2, observations of the application of NaCl concentration to Karya Pelalawan rice seeds on the average value of the FCT test percentage that has germinated, the highest was in treatment P1 (Concentration of 2,500 ppm) at 5.0% and the lowest was in treatment P4 (Concentration of 10,000 ppm) at 0.5%. Seeds that germinate faster are indicated by high percentage values. This value indicates that stress affects the delay in the initial germination process. Under normal conditions, seeds with high vigor will generally show a fairly high percentage of initial germination. However, under stress conditions such as drought, salinity, high temperatures or osmotic stress can slow down the physiological processes that are important in the early stages of seed germination.

The treatment with a tolerant NaCl concentration was P1. The ability of seeds to continue germination despite being delayed indicates a physiological resistance that continues to function even under environmental stress. This is an important indicator in evaluating the potential for seed adaptation to less-than-ideal field conditions. The low results of this first test were caused by disruption of the imbibition process (water absorption) and the activity of enzymes needed to break down food reserves in the seeds. Suboptimal environmental conditions can inhibit seed metabolism (Lavenia, 2022). According to Ashar *et al.* (2024), environmental stress can activate protective mechanisms in seeds, causing them to delay germination until conditions are more favorable.

3.2 Percentage of Germination Power

Germination testing aims to determine the percentage of seeds that can grow normally under certain conditions. The results of the seed germination test obtained the percentage (%) of germination of Karya Pelalawan rice seeds. The germination percentage results can be seen in Table 3.

Based on Table 3, observations of the application of NaCl concentration to Karya Pelalawan rice seeds on the average germination percentage, the highest was in treatment P1 (2,500 ppm concentration) at 10.0% and the lowest was in treatment P4 (10,000 ppm) at 1.5%. According to Humadini (2011), germination can be defined as the ability of seeds to bloom or develop vital parts of the embryo to grow normally in a suitable environment. According to Kesmayanti & Romza (2022), at a concentration limit that is still tolerable for seeds, the diffusion of NaCl solution into the seeds breaks seed dormancy, because the absorption of imbibition water will encourage metabolic changes in the seeds. These metabolic changes will encourage cell growth in the embryo. Imbibition water will stimulate the swelling of colloids and proteins in the seeds, which will encourage the breakdown of the seed coat. This will then encourage germination, so it is closely related to germination power.

Table 3. Germination power (%) of Karya Pelalawan variety rice seeds under salinity stress.

Treatment	(%)
P0	7.5
P1	10.0
P2	9.5
P3	5.0
P4	1.5

Based on Table 3, it can be seen that the higher the NaCl concentration given, the lower the resulting percentage value. Treatment P1 with a concentration of 2,500 ppm had a germination percentage of 10.0% higher compared to treatments P3 and P4 with concentrations of 7,500 ppm and 10,000 ppm which had germination percentages of 5.0% and 1.5%. This indicates that the treatment of a higher concentration of NaCl resulted in a lower germination percentage compared to the treatment without the addition of NaCl concentration. This is suspected because the high concentration causes low germination due to the inhibition of rice seed germination.

The treatment with a tolerant NaCl concentration was P1. This NaCl concentration affected the germination of rice plants. This is thought to be because the salt solution plays a role in regulating the density of water. Adding salt to water will lower the density of water and remove empty and low-quality seeds, so that only quality seeds will be used, resulting in a higher germination percentage (Kesmayanti & Romza, 2022). Germination is an important parameter in assessing rice seed quality. Germination indicates the ability of seeds to grow into normal seedlings under optimal conditions. Normal seedlings are those that have a complete structure and can develop into healthy plants. Normal seedlings have well-developed primary roots and shoots without morphological abnormalities (ISTA 2023).

3.3 Germination rate

Germination rate can be used to determine seed response to a given treatment. The results of the seed germination rate test can be seen in Table 4.

Table 4. Germination rate of Karya Pelalawan variety rice seeds under salinity stress.

Treatment	Germination rate
P0	8.79
P1	11.07
P2	7.44
P3	5.06
P4	3.22

Description: P0 (Concentration 0 ppm), P1 (Concentration 2,500 ppm), P2 (Concentration 5,000 ppm), P3 (Concentration 7,500 ppm), P4 (Concentration 10,000 ppm).

Based on Table 4, observations of the application of NaCl concentration to Karya Pelalawan rice seeds showed that the average germination percentage was highest in treatment P1 (2,500 ppm concentration) at 11.07, and the lowest in treatment P4 (10,000 ppm) at 3.22. This means that the application of NaCl concentration affects the germination rate of Karya Pelalawan rice seeds. According to Dahono *et al.* (2020), stress treatment using NaCl affects germination rate. Increasing NaCl concentrations in rice reduces the rice's ability to grow, influenced by the rice's ability to grow under stress. Higher salinity in the environment (planting medium) will affect the internal state of the rice, such as damaging the seed's food reserves, which can inhibit germination.

Based on Table 4, germination rate is an important indicator in assessing seed vigor. Germination rate indicates how quickly seeds begin to grow into normal seedlings within a certain time after planting or testing begins. The faster the seeds germinate, the higher the seed vigor, which indicates the seed's ability to develop optimally in the field (Megasari, 2022). According to Barus & Rauf (2021), salinity causes high levels of hydroxide ions, which can cause stress to plants and reduce their growth capacity. Hydroxide ions are present due to the presence of excess calcium, magnesium, and sodium carbonate.

3.4 Growth of radicle and plumule of sprouts

The results of post hoc tests on radicle and plumule that have been carried out on Karya Pelalawan variety rice seeds can be seen in Table 5.

Table 5. Radicle and plumule growth in Karya Pelalawan variety rice seeds

Treatment	Radicule (cm)	Plumule (cm)
P0	5.75 a	5.16 a
P1	7.62 a	7.43 b
P2	7.67 a	7.45 b
P3	6.70 a	6.62 b
P4	7.19 a	7.26 b

Note: P0 (Concentration 0 ppm), P1 (Concentration 2,500 ppm), P2 (Concentration 5,000 ppm), P3 (Concentration 7,500 ppm), P4 (Concentration 10,000 ppm). Numbers followed by the same letter indicate no significant difference based on the 5% DMRT test.

Table 5 shows that the NaCl concentration applied to Karya Pelalawan rice seeds did not significantly differ between all treatments in terms of radicle growth. However, in terms of plumule growth, NaCl application did not significantly differ between treatments P1 to P4, but significantly differed from treatment P0. Based on the observations, it can be seen that the rice seedlings were classified as normal seedlings because the radicle was longer than the plumule. According to Mustaqimah *et al.* (2020), the longest root/radicle growth is significantly influenced by carbohydrate content and food reserves for initial energy for root/radicle growth, which is influenced by the environment, division, cell elongation, and rapid tissue formation.

Based on Table 5, the NaCl concentration that tended to produce the longest radicle length was P2. According to Supardy *et al.* (2016), the formation of new cells in the embryo is followed by a process of cell differentiation, resulting in the formation of the radicle, which is the root primordia, and the plumule, which is the leaf primordia. These two parts will increase in length and size, ultimately leading to seed germination. The gibberellin hormone acts as a catalyst in the conversion of starch into glucose by the seed, which is used for the growth and development of the embryo into a sprout. If the plumule is longer than the radicle, this can be caused by high humidity, which stimulates plumule growth first (Azmi *et al.*, 2022). This can also occur when the plant is inundated with water. Plumules that are longer than the radicle are classified as abnormal sprouts. Some plants can adapt well to environments with high salt concentrations (halophytes), but most plants, including rice, will experience stunted growth in such environments (glycophytes) (Dahono *et al.,* 2020).

3.5 Vigor Test

The vigor test aims to determine the ability of rice seeds to germinate under normal conditions in suboptimal environmental conditions (Zani & Anhar, 2021). The results of the rice seed vigor test obtained the average vigor percentage of seeds of the Karya Pelalawan variety. The observation data from the seed vigor test can be seen in Table 6.

Table 6. Percentage of seed vigor test (%) on Karya Pelalawan variety seeds

Treatment	(%)
P0	80
P1	92.2
P2	84.2
P3	72.4
P4	62.2

Description: P0 (Concentration 0 ppm), P1 (Concentration 2,500 ppm), P2 (Concentration 5,000 ppm), P3 (Concentration 7,500 ppm), P4 (Concentration 10,000 ppm).

Based on Table 6, observations of the application of NaCl concentration to Karya Pelalawan rice seeds on seed vigor tests showed that the highest was in treatment P1 (2,500 ppm concentration) at 92.2% and the lowest was in treatment P4 (10,000 ppm) at 62.2%. The treatment of NaCl concentration affected seed vigor in treatments P1 and P2, this is because in treatments P3 and P4 the percentage of rice seed vigor tests was lower compared to P0, which is without concentration (0 ppm). This is not much different from research (Azmi, *et al.,* 2022) which stated that the vigor test for Karya Pelalawan rice seeds soaked for 16 hours was 96%. There was no significant effect even though saline stress was given. This can be seen in the context of the general physiological quality of seeds.

Table 6 shows the effect of NaCl concentration on seed condition. This indicates that the stress treatment in this study actually stimulated seed adaptation and increased germination and initial growth, especially at P2. This positive response indicates that the stress applied was still within the physiological tolerance limits of the seeds and could even trigger seeds to be more prepared to grow in less than ideal field conditions. Thus, stress treatment can be a potential strategy to improve seed performance before planting in the field. Seeds with high vigor can be seen by the faster germination of seeds. High-vigor seeds also have high germination, but seeds with high germination do not necessarily have high vigor (Azmi *et al.,* 2022).

3. Kesimpulan

NaCl application affected the viability and vigor of Karya Pelalawan rice seeds, as reflected in the first count test (FCT) percentage, germination rate, germination rate, radicle and plumule growth, and seed vigor test. The tolerable NaCl concentration (P1, 2,500 ppm) provided the best results in FCT, germination rate, germination rate, and vigor test parameters.

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