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Utilizing Eco-enzyme for Dormancy Breaking and Germination in Certified Rice Seed Testing

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Abstract

Rice is one of the primary food commodities as a staple food in Indonesia. Increasing rice production can be done by using certified seeds. Dormancy is one of the obstacles in the rice seed testing process. Eco-enzyme is expected to be used for breaking dormancy and promoting germination in certified rice seed testing. This study aims to determine the optimal concentration and soaking time of Eco-enzyme in breaking dormancy of Inpari 32 HDB rice seeds and to assess the potential of Eco-enzyme in replacing KNO_3 0.2% in breaking dormancy of Inpari 32 HDB rice seeds. This research was conducted in the seed quality testing laboratory of UPTD Food Crop and Horticultural Seed Certification, North Sumatra Province, from September to October 2024. The results of the study showed that the use of eco-enzyme with concentrations of 5%, 10%, and 15% and a soaking period of 24 and 48 hours did not show a significant difference or a significantly increased effect on various germination parameters compared to the use of KNO_3.

Keywords: Dormancy, Eco-Enzyme, Inpari 32 HDB rice, KNO_3

1. Introduction

Rice is one of the most widely cultivated plants in Indonesia, where it is a staple food of the Indonesian people. The Central Statistics Agency (2023) reported that the harvested area and rice production in Indonesia is estimated at 10.20 million hectares, with rice production of around 53.63 million tons of dry-milled grain.

The most widely used rice variety in the North Sumatra region is the Inpari 32 HDB variety, as evidenced by the area of rice seed certification in North Sumatra. Based on the final report of the food crop seed system management activities for the 2023 budget year, it is known that the largest certification area, based on variety, is the Inpari 32 HDB variety, which covers 665.74 Hectares of the 1,390 Hectares of the certification area (SBTPH, 2023).

High and good rice production can be achieved through several factors, one of which is the use of seeds that meet high-quality standards. Therefore, when producing rice, it is highly recommended to use certified seeds. Certified seeds are produced through supervision that starts from the nursery, continues through planting and harvesting, and concludes with laboratory testing. Some of the advantages of using certified seeds include a reduced number of seeds required, higher production yields due to better seed quality, increased resistance to pests and diseases, and others (Puspitasari, 2017).

The implementation of quality control and certification for food crop seeds requires seed sampling and testing/analysis of seed quality. Seed quality testing and analysis are necessary to evaluate seed quality, which includes physical quality (determination of water content and purity analysis) and physiological quality (germination testing and analysis) carried out on each group of seeds. Germination testing in the laboratory aims to determine the maximum germination potential of a group of seeds, which can then be used to compare seed quality between different groups and estimate planting values in the field (Kepmentan RI, 2022).

Seed germination testing is conducted to assess the ability of seeds to germinate and grow in the field. Germination testing in the laboratory uses the between-paper method, then incubated for 5 to 14 days in a germinator at a temperature of 25 °C ± 2. However, in this rice germination test, dormant seed conditions are often

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encountered, resulting in non-uniform germination times and levels, which in turn renders the germination test evaluation results inaccurate. To overcome this, on the 5th day of testing, the first germination observation will be conducted. If the initial observation results indicate that germination is less than 80% and fresh seeds do not grow significantly, dormancy is broken using 0.2% KNO3 (ISTA Rules, 2021).

Breaking rice seed, dormancy can be overcome in various ways, such as scarification, using H2SO4 solution, KNO3 solution, GA3, and also using eco-enzymes. Research on breaking dormancy using eco-enzymes has been carried out, including breaking coffee seed dormancy by Anindita (2023).

The NPK nutrient content of Eco-enzyme is still below the quality standard for liquid organic fertilizer, but the enzymes contained in it can stimulate plant growth. The N content in Eco-enzyme is in the form of NO3 (Nitrate), allowing it to be easily absorbed by plants. Additionally, enzymes play a role in promoting meristem division and stimulating root and leaf growth (Fadlilla et al., 2023).

Research on the use of eco-enzymes to break dormancy has been widely conducted on several types of seeds; however, for rice seeds, the number of studies is still limited. Therefore, the author aims to conduct this research to determine the potential of eco-enzymes, concentrations, and the optimal soaking time in breaking the dormancy of rice seeds, especially for Inpari 32 HDB rice seeds.

2. Material and Methods

The research was conducted at the Seed Quality Testing Laboratory, UPTD. Food Crops and Horticulture Seed Certification, Food Security, Food Crops and Horticulture Service of North Sumatra Province, from May 2024 to October 2024. The flow diagram of this research can be seen in the following picture:

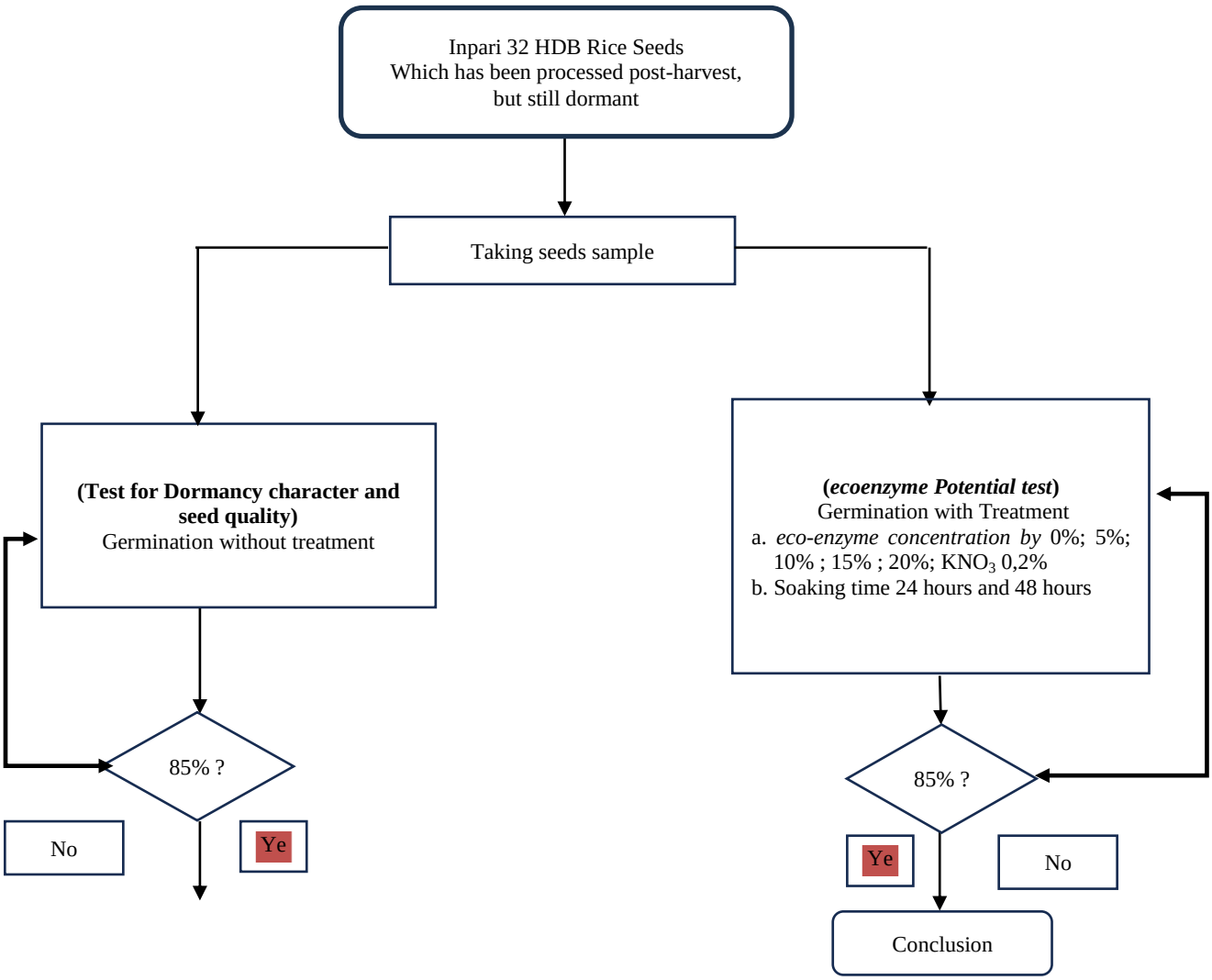

Figure 1. Research Flow Diagram

The materials used in this study were Inpari 32 variety rice seeds taken from PT. Benih Inti Prima, in Pantai Cermin Kiri Village, Pantai Cermin District, Serdang Bedagai Regency (3 0 36'14", 98 0 58'47" 5.6 masl), which

were harvested on September 14, 2024, eco-enzyme, KNO3, water, paper and other materials that support this study.

The tools used in this study included a germinator, oven, porcelain cup, desiccator, tweezers, analytical balance, beaker glass, shaker, laptop, stationery, and other tools that supported this study.

This study is divided into two parts: testing the quality and character of seed dormancy and testing the potential of eco-enzymes in breaking dormancy. The quality and character of dormancy were tested on seeds without any treatment, aiming to assess the actual quality of the seeds. Meanwhile, the potential test of eco-enzyme was conducted to evaluate the quality of the seeds after treatment. Testing was carried out on newly harvested seeds that remained dormant until they broke their dormancy, with a seven-day interval between tests.

The design used in this study was a Factorial Randomized Block Design (RAK) with two treatment factors, the first factor was the use of eco-enzyme solution with several levels, namely 0.2% KNO3 as a control (K0), 0% eco-enzyme solution (K1), 5% eco-enzyme solution (K2), 10% eco-enzyme solution (K3), 15% eco-enzyme solution (K4), and 20% eco-enzyme solution (K5) and the second factor was the soaking time, namely for 24 hours (W1) and for 48 hours (W2) each treatment combination was repeated 4 times to obtain 48 test units. This study employed the Randomized Block Design method, utilizing two treatment factors, and was analyzed using the IBM SPSS Statistics 25 application.

Parameter observations were conducted every 7 days after testing until the seeds were considered to have broken dormancy, specifically after the germination percentage reached ≥ 85%. The parameters observed were the volume of water absorbed by the seeds (ml), the number of normal sprouts (%), vigor index (%), maximum growth potential (PTM) (%), growth rate (%etmal), and growth simultaneity (%).

3. Results and Discussion

3.1. Testing of Dormancy Character and Seed Quality

Dormancy character testing and seed quality testing were conducted on Inpari 32 HDB rice seeds that were not subjected to soaking treatment. Instead, they used newly harvested seeds that had undergone a post-harvest process in compliance with technical standards for seed certification. This testing was conducted to determine whether the character and quality of the seeds tested were correct and followed the quality standards for quality seeds.

The dormancy characteristics observed in this study were dormancy intensity and dormancy persistence. Dormancy intensity describes the number of dormant seeds at harvest time, while dormancy persistence refers to the time required for seeds to germinate and reach 85% or more.

Measurement of dormancy intensity parameters is conducted by testing the germination power of seeds when they are newly harvested, and the percentage of dormant seeds is a reflection of the dormancy intensity of the rice seeds. The dormancy intensity of the seeds tested in this study is presented in the table below.

Table 1. Number of sprouts experiencing dormancy on the 7th day after testing.

Sprouts Criteria	Test				
	I	II	III	IV	Average
Normal	16	18	11	9	13.5
Abnormal	11	10	13	11	11.2
BSTT	71	72	74	78	73.8
BM	2	0	2	4	2.0

The dormancy intensity obtained from the results of the Inpari 32 HDB seed test was 73.8%. The percentage taken was the number of seeds that fell into the criteria of fresh seeds that did not grow. Fresh seeds that did not grow are seeds that can absorb water but have not been able to germinate due to the dormancy conditions they experienced.

Observation of dormancy persistence is carried out by testing seed germination power, which is conducted every week until the percentage of germination reaches 85% or more.

Table 2. Dormancy breaking time for rice seeds to achieve germination power ≥ 85%

Treatment	1 MSP	2 MSP	3 MSP
Normal	75.25	84.75	86.50
Abnormal	4.25	4.00	3.25
BSTT	18.50	10.00	9.50
BM	2.00	1.25	0.75

The results of the germination power test conducted showed persistence of dormancy or a percentage of germination power ≥ 85% obtained in the 2nd week after harvest.

The results of the dormancy character test showed that the dormancy intensity of Inpari 32 HDB rice seeds was

73.8%, while the dormancy persistence was obtained for 2 weeks. The dormancy intensity does not align with the results of research conducted by Yuningsih and Wahyuni (2020). Still, for dormancy persistence, a germination power of 84.75% was obtained, which is very close to 85%. This point indicates that the dormancy persistence of Inpari 32 HDB seeds is in accordance with the study, specifically 2 weeks after harvest.

The seed quality testing conducted includes fresh seed weight, dry seed weight, water content, thousand-grain weight, seed purity, and viability. Data on the results of seed quality testing can be seen in the following table:

Table 3. Seed Quality Test Result Data

Sunday	Fresh weight (g)	Dry weight (g)	Water content (%)	Weight of a Thousand Grains (g)	Purity (%)	Viability (%)
I	2.83	2.55	11.7	28.17	99.9	99
II	2.87	2.57	11.2	28.77	99.9	99
III	2.85	2.58	10.4	28.43	99.9	99

The results of seed quality testing showed that the highest fresh seed weight and thousand-grain weight occurred in the second week after harvest, at 2.87 g. The highest dry weight was recorded in the third week, at 2.58 g, while the lowest water content was observed in the third week after harvest. For seed purity and seed viability, the results were consistent from the first week to the third week, with values of 99.9% and 99%, respectively.

The test results data illustrate that the quality of the seeds is classified as good quality seeds; this can be seen from the viability and purity of the seeds where the viability or ability to live is 99% and the purity of the seeds is 99.9%, as well as the water content which is below 13% where the water content is the water content that is suitable for seed storage and the seed germination process. The data above follow the requirements for quality seeds as outlined in the seed regulations of the Ministry of Agriculture, No. 966 of 2022, concerning technical instructions for food certification.

3.2. Testing the Potential for Breaking Rice Seed Dormancy Using Eco-enzyme

3.2.1. Volume of water absorbed by seeds (ml)

The study's results showed that the eco-enzyme had a significant effect on the volume of water absorbed by the seeds. The results of further tests are presented in Table 4.

The interaction of the soaking treatment using eco-enzyme with a wet time of 24 hours did not show a significant difference between KNO3 and eco-enzyme. At a soaking time of 48 hours, a significant difference was observed in the wet treatment using pure water. In contrast, between eco-enzyme and KNO3, there was no significant difference, with the highest absorption volume in the pure water immersion treatment of 0.87 ml.

Table 4. The volume of water absorbed by seeds after being treated with Ecoenzyme and KNO3 soaking.

Treatment	Volume absorbed (ml)		
	1 MSP	2 MSP	3 MSP
K0 = $_{KNO3}$	0.67 ± 0.01 bc	0.64 ± 0.01 b	0.68 ± 0.04 b
K1= 0 %	0.78 ± 0.02 a	0.74 ± 0.02 a	0.78 ± 0.03 a
K2 = 5%	0.66 ± 0.01 bc	0.66 ± 0.01 b	0.69 ± 0.02 b
K3 = 10%	0.67 ± 0.01 bc	0.63 ± 0.02 b	0.68 ± 0.03 b
K4 = 15%	0.68 ± 0.02 b	0.63 ± 0.03 b	0.67 ± 0.02 b
K5 = 20%	0.66 ± 0.01 c	0.64 ± 0.02 b	0.68 ± 0.03 b
W = Soaking Time			
W1 = 24 Hours	0.65 ± 0.04 b	0.61 ± 0.03 b	0.65 ± 0.02 b
W2 = 48 Hours	0.72 ± 0.05 a	0.70 ± 0.05 a	0.74 ± 0.06 a
K0W1	0.64 ± 0.01 ns	0.60 ± 0.01 ns	0.65 ± 0.07 de
K1W1	0.73 ± 0.04 ns	0.68 ± 0.04 ns	0.69 ± 0.04 bcd
K2W1	0.62 ± 0.02 ns	0.60 ± 0.01 ns	0.66 ± 0.02 cde
K3W1	0.66 ± 0.01 ns	0.59 ± 0.01 ns	0.65 ± 0.04 de
K4W1	0.65 ± 0.02 ns	0.59 ± 0.01 ns	0.63 ± 0.02 e
K5W1	0.62 ± 0.02 ns	0.59 ± 0.00 ns	0.65 ± 0.05 de
K0W2	0.70 ± 0.02 ns	0.68 ± 0.01 ns	0.71 ± 0.01 bc
K1W2	0.82 ± 0.02 ns	0.80 ± 0.03 ns	0.87 ± 0.05 a
K2W2	0.71 ± 0.02 ns	0.72 ± 0.00 ns	0.72 ± 0.02 b
K3W2	0.69 ± 0.00 ns	0.68 ± 0.04 ns	0.72 ± 0.01 b
K4W2	0.70 ± 0.04 ns	0.67 ± 0.06 ns	0.71 ± 0.02 bc
K5W2	0.69 ± 0.03 ns	0.68 ± 0.04 ns	0.72 ± 0.01 b

Description: Numbers followed by different letters in the same treatment group are significantly different at the 5 % level based on the DMRT test, while those without annotations indicate no significant difference.

3.2.2. Germination Power (Number of normal sprouts) (%)

Eco-enzyme soaking treatment and soaking time significantly affected the number of normal sprouts in 2- and 3-MSP seeds but did not substantially affect the 1-MSP seed.

Eco-enzyme soaking with a 24-hour soaking time did not show a significant difference in the percentage of normal sprouts in 1 MSP seed. Still, in 2 MSP seeds, it significantly increased the percentage of normal sprouts compared to KNO3. A soaking time of 48 hours significantly increased the number of normal sprouts at eco-enzyme concentrations K2-K4 and was not substantially different from KNO3 at concentration K5.

Eco-enzyme treatment with a 48-hour soaking time was not significantly different between KNO3 and eco-enzyme at all concentration levels in 3 MSP seeds. For 1 MSP seeds, the highest number of normal sprouts was observed in the K4W2 treatment, at 89.75%. In 2 and 3 MSP seeds, the highest percentage of normal sprouts was observed in the K2W2 treatment, at 95% and 96.75%, respectively. The results of further tests of normal sprouts obtained after soaking treatment can be seen in the following table:

Table 5. Percentage of normal sprouts after being treated with Eco-enzyme and KNO3 soaking.

Treatment	Normal Sprouts (%)		
	1 MSP	2 MSP	3 MSP
K0 = $_{KNO3}$	75.50 ± 4.22 b	87.00 ± 3.14 b	94.13 ± 1.18 b
K1 = 0 %	73.25 ± 3.52 b	87.75 ± 2.22 b	90.38 ± 2.32 c
K2 = 5%	85.38 ± 1.18 a	93.13 ± 1.70 a	93.13 ± 1.49 abc
K3 = 10%	87.13 ± 1.25 a	92.50 ± 1.35 a	94.88 ± 1.11 a
K4 = 15%	86.50 ± 0.71 a	93.13 ± 0.85 a	93.88 ± 0.85 ab
K5 = 20%	85.25 ± 3.71 a	88.13 ± 0.75 b	91.63 ± 1.55 bc
W = Soaking Time			
W1 = 24 Hours	79.71 ± 6.50 b	88.75 ± 4.18 b	92.63 ± 2.03 ns
W2 = 48 Hours	84.63 ± 6.03 a	91.79 ± 3.78 a	93.38 ± 3.27 ns
K0W1	74.75 ± 3.86 ns	83 .00 ± 4.69 b	95.25 ± 3.30 ab
K1W1	68.75 ± 7.80 ns	83.75 ± 4.79 b	91.25 ± 3.77 bc
K2W1	82.5 ± 3.32 ns	91.25 ± 2.22 a	89.50 ± 2.08 c
K3W1	85.00 ± 2.45 ns	91,00 ± 2.45 a	93.50 ± 1.73 abc
K4W1	83.25 ± 3.77 ns	92 .00 ± 1.41 a	92.50 ± 2.65 abc
K5W1	84.00 ± 6.53 ns	91.50 ± 1.00 a	93.75 ± 1.50 abc
K0W2	76.25 ± 5.12 ns	91 .00 ± 3.16 a	93.00 ± 1.83 abc
K1W2	77.75 ± 1.71 ns	91.75 ± 3.30 a	89.50 ± 2.08 c
K2W2	88.25 ± 5.32 ns	95.00 ± 1.41 a	96.75 ± 2.50 a
K3W2	89.25 ± 4.57 ns	94.00 ± 1.15 a	96.25 ± 2.06 a
K4W2	89.75 ± 2.75 ns	94.25 ± 1.26 a	95.25 ± 2.50 ab
K5W2	86.50 ± 1.29 ns	84.75 ± 2.36 b	89.50 ± 3.42 c

Description: Numbers followed by different letters in the same treatment group are significantly different at the 5% level based on the DMRT test, while those without annotations indicate no significant difference.

Based on the results of this study, it can be seen that eco-enzyme can replace KNO3 in increasing the number of normal sprouts at all concentration levels; this result is thought to be due to soaking seeds using eco-enzyme solution being able to soften the rice seed coat so that the imbibition process can occur, this is following the statement of Seshu and Dadlani (2008) who revealed that the cause of dormancy in rice seeds is the impermeability of the rice coat which causes oxygen to be blocked from entering the rice seeds. Imbibition is the initial stage of the germination process, which enables the entry of water, oxygen, and nutrients from the solution into the seeds, allowing the metabolic process to occur within them.

From the data in Table 4, it can also be seen that the highest volume of water absorbed was in the K0 treatment, which involved 0% eco-enzyme or only pure water. Still, even though the volume of water absorption was the highest, the seed germination power tended to be lower than that of the KNO3 treatment and the eco-enzyme. This point is because germination requires not only water but also nutrients that can stimulate the process. The data from this study align with research conducted by Anindita (2023), which shows that eco-enzyme is effective in breaking coffee bean dormancy, particularly due to its ability to soften the endosperm and activate the imbibition process and early metabolism. It is known that the KNO3 solution and eco-enzyme solution contain nutrients, primarily N and K nutrients; this result follows research conducted by Zirrazaq and Putri (2022), where seeds treated with eco-enzyme gave better results in terms of germination than those not given eco-enzyme, this is due to the Nitrogen content in the eco-enzyme.

3.2.3. Vigor Index (%)

Soaking using eco-enzyme has a significant effect on the seed vigor index; the data from further tests on seed vigor can be seen in the following table:

Table 6. Seed Vigor Index after being treated with Eco-enzyme and KNO 3 soaking.

Treatment	Vigor Index (%)		
	1 MSP	2 MSP	3 MSP
K0 = $_{KNO3}$	66.38 ± 2.87 b	80.38 ± 2.87 b	88.00 ± 1.58 ab
K1 = 0 %	55.50 ± 4.71 c	80.13 ± 3.40 b	82.63 ± 2.93 c
K2 = 5%	76.50 ± 2.04 a	83.25 ± 1.71 b	89.75 ± 2.50 a
K3 = 10%	76.25 ± 2.60 a	89.00 ± 1.41 a	87.25 ± 1.66 ab
K4 = 15%	74.75 ± 1.85 a	84.75 ± 3.77 ab	85.75 ± 2.53 bc
K5 = 20%	64.38 ± 5.50 b	75.13 ± 3.90 c	73.13 ± 3.20 d
W = Soaking Time			
W1 = 24 Hours	67.08 ± 5.27 b	79.21 ± 5.62 b	83.50 ± 4.01 a
W2 = 48 Hours	70.83 ± 11.78 a	85.00 ± 5.91 a	85.33 ± 8.90 b
K0W1	65.75 ± 2.06 cd	73.50 ± 5.97 e	88.25 ± 2.99 ab
K1W1	57.50 ± 8.81 ef	73.75 ± 7.50 e	81.25 ± 2.63 cd
K2W1	71.25 ± 3.50 bc	83.75 ± 4.57 bc	88.00 ± 2.83 ab
K3W1	70.25 ± 3.77 bcd	87.00 ± 3.37 abc	82.00 ± 2.58 cd
K4W1	71.25 ± 2.87 bc	81.25 ± 6.65 cd	83.50 ± 5.80 bc
K5W1	66.50 ± 7.05 cd	76.00 ± 3.74 de	78.00 ± 2.58 d
K0W2	67.00 ± 6.22 cd	87.25 ± 2.50 abc	87.75 ± 3.40 ab
K1W2	53.50 ± 4.73 f	86.50 ± 1.29 abc	84.00 ± 3.56 bc
K2W2	81.75 ± 4.65 a	82.75 ± 1.71 bc	91.50 ± 3.79 a
K3W2	82.25 ± 4.65 a	91.00 ± 6.65 a	92.50 ± 2.38 a
K4W2	78.25 ± 3.30 ab	88.25 ± 0.96 ab	88.00 ± 3.16 ab
K5W2	62.25 ± 6.34 de	74.25 ± 4.11 e	68.25 ± 4.92 e

Description: Numbers followed by different letters in the same treatment group are significantly different at the 5% level based on the DMRT test, while those without annotations indicate no significant difference.

The soaking treatment using eco-enzyme at concentrations of K2, K3%, K4%, and K5% for 24 hours on seed vigor at 1 MSP was not significantly different from KNO3. However, at 2 MSP, it was significantly higher using eco-enzyme in treatments K2, K3, and K4, but not significantly different at concentration K5. The highest vigor index was seen at concentration K3, which was 87%. The concentration of eco-enzyme K2 was not considerably different from KNO3 in increasing the vigor index in seeds at 3 MSP. Still, it significantly decreased the vigor index at concentrations K1, K3, K4, and K5, where the KNO3 treatment showed a higher vigor index than the eco-enzyme.

A 48-hour soaking period significantly increased the vigor index of 1 MSP and 2 MSP seeds compared to a 24-hour soaking period but was not significantly different for 3 MSP seeds.

The 48-hour soaking treatment significantly increased the vigor index in soaking using eco-enzymes K2, K3, and K4 compared to using KNO3, but was not significantly different at the K5 concentration. At 2 MSP and 3 MSP, soaking using eco-enzyme and KNO3 did not show a significantly different effect on the vigor index at the K2-K4 concentration; however, it significantly decreased the vigor index at the K5 concentration. It is suspected that in 2 and 3 MSP seeds, the seeds have begun to experience dormancy breakage so that the food reserves in the seeds are sufficient for the metabolic process so that the provision of eco-enzyme with a high concentration does not have a good effect on germination, because at this time the seed weight is optimal, so that the intake of nutrients will stop due to swelling of food reserves, this is following the statement of Bewley et al. (2013). The highest vigor index was observed in the K3W2 treatment for 1, 2, and 3 MSP seeds, with vigor index percentages of 82.25%, 91%, and 92.5%, respectively. This finding is also in accordance with research conducted by Zirrazaq and Putri (2022) on chili seeds, which showed a decrease in radicle length at concentrations that were too high. Prolonged soaking reduced effectiveness due to the possibility of toxicity or seed hypersensitivity to the solution.

3.2.4. Maximum Growth Potential (PTM) (%)

The administration of eco-enzymes with concentrations of K2, K3, K4, and K5, along with a 24-hour soaking period, significantly increased the maximum growth potential of seeds compared to the KNO3 treatment on seeds of MSP 1 and 2. Still, the effect of eco-enzyme administration was not significantly different from KNO3 on seeds of 3 MSP. In the treatment of eco-enzyme administration with a soaking period of 48 hours for seeds tested at 1 MSP, the administration of eco-enzyme significantly increased the percentage of PTM at concentrations of K2, K3, and K5 compared to the administration of KNO3, while at concentration K4 it was not significantly different from the administration of KNO 3. In seeds of 2 MSP and 3 MSP, the administration of eco-enzyme with concentrations K3, K4, and K5 was not significantly different from the administration of KNO3 but significantly increased the percentage of PTM at concentration K2. The highest PTM percentage was observed in the K2W2 treatment, at 91% for 1 MSP, 96.50% for 2 MSP, and 98.75% for 3 MSP. Data from the

PTM follow-up test results are presented in Table 7.

Table 7. Maximum growth potential of rice seeds after treatment with eco-enzyme and KNO3 soaking.

Treatment	PTM (%)		
	1 MSP	2 MSP	3 MSP
K0 = $_{KNO3}$	80.13 ± 3.77 b	90.13 ± 2.32 b	95.25 ± 1.32 ab
K1 = 0 %	77.25 ± 3.12 b	90.13 ± 1.93 b	92.50 ± 2.27 c
K2 = 5%	88.38 ± 1.62 a	94.75 ± 1.19 a	97.13 ± 1.03 a
K3 = 10%	88.75 ± 1.55 a	94.13 ± 1.11 a	96.13 ± 1.11 a
K4 = 15%	88.88 ± 2.63 a	94.25 ± 0.50 a	96.25 ± 0.96 a
K5 = 20%	90.25 ± 1.50 a	92.50 ± 1.08 a	93.75 ± 1.19 bc
W = Soaking Time			
W1 = 24 Hours	84.38 ± 6.97 b	91.04 ± 3.14 b	95.21 ± 0.97 a
W2 = 48 Hours	86.83 ± 4.58 a	94.25 ± 1.70 a	95.13 ± 2.91 a
K0W1	79.25 ± 3.77 d	87.25 ± 3.59 d	95.75 ± 3.40 abc
K1W1	73.00 ± 5.48 e	86.75 ± 3.77 d	93.25 ± 3.40 cd
K2W1	85.75 ± 2.99 abc	93.00 ± 1.83 bc	95.50 ± 1.73 abc
K3W1	87.00 ± 2.16 ab	92.75 ± 1.71 bc	95.50 ± 1.29 abc
K4W1	91.00 ± 3.16 a	93.50 ± 1.29 abc	95.50 ± 1.00 abc
K5W1	90.25 ± 1.50 a	93.00 ± 1.41 bc	95.75 ± 1.26 abc
K0W2	81.00 ± 4.69 cd	93.00 ± 2.16 bc	94.75 ± 1.50 bcd
K1W2	81.50 ± 2.08 bcd	93.50 ± 1.73 abc	91.75 ± 2.06 d
K2W2	91.00 ± 5.29 a	96.50 ± 1.29 a	98.75 ± 1.26 a
K3W2	90.50 ± 4.43 a	95.50 ± 2.08 ab	96.75 ± 2.22 abc
K4W2	86.75 ± 4.92 abc	95.00 ± 0.82 abc	97.00 ± 2.00 ab
K5W2	90.25 ± 1.50 a	92.00 ± 1.15 c	91.75 ± 2.75 d

Description: Numbers followed by different letters in the same treatment group are significantly different at the 5% level based on the DMRT test, while those without annotations indicate no significant difference.

Based on the results of the study, it can be seen that the maximum growth potential (PTM) in seeds treated with eco-enzyme soaking showed higher results compared to treatments using water and KNO3; this result is thought to be due to the acidic nature and N content in the eco-enzyme used in this study, which is 0.04%, encouraging the activity of hydrolytic enzymes. During the germination process, the developing embryo stimulates the emergence of substances that cause transcription of several marker genes for hydrolytic enzymes, including α-amylase. Then, the enzyme enters the endosperm and hydrolyzes starch and protein, serving as a food source for embryo development. This finding aligns with research conducted by Wahyuni et al. (2023), which suggests that seeds with high enzyme activity also exhibit a high maximum growth potential.

3.2.5. Growth Rate (%)

Based on the research results in Table 8, it is evident that the provision of eco-enzyme and KNO3 with a soaking time of 24 hours did not significantly increase the growth rate of rice seeds, regardless of the concentrations of K2, K3, K4, and K5 tested at 1 MSP. For seeds tested at 2 MSP, the provision of eco-enzyme concentrations K2 and K3 significantly increased the growth rate compared to KNO3, while at concentrations K4 and K5, there was no significant difference. At 3 MSP, the provision of eco-enzyme with concentrations of K2, K3, and K4 did not significantly differ from KNO3, but it significantly reduced the growth rate of seeds at concentration K5.

In the 48-hour soaking treatment for seeds tested at 1 MSP, the provision of eco-enzyme with concentrations of K2 and K3 significantly increased the growth rate compared to the provision of KNO3, where the highest growth rate was at the K3 concentration, which was 58.50% etmal. Still, the provision of eco-enzyme at concentrations K4 and K5 was not significantly different from that of KNO3. In the seeds tested at 2 MSP, the provision of eco-enzyme and KNO3 did not significantly differ in increasing the growth rate for concentrations of K2 to K4 but significantly decreased the growth rate at concentrations of K5. The effect of KNO3 and eco-enzyme K2 significantly increased the growth rate for seeds at 3 MSP but was not significantly different at concentrations of K3 and K5. The provision of eco-enzyme with a concentration of K5 significantly decreased the seed growth rate. For 2 MSP seeds, the highest growth rate was obtained in the K1W2 treatment, which was 69.25% etmal. For 3 MSP seeds, the highest growth rate was obtained in the K2W2 treatment, which was 70.75% etmal. The provision of eco-enzyme significantly increased the growth rate of rice seeds, and this result can be seen from the length of the dormancy breaking period after being given eco-enzyme, which only took one week; this is faster than the research of Yuningsih and Wahyuni (2016) which stated that Inpari 32 HDB rice seeds have a dormancy period of 2-3 weeks.

Table 8. The growth rate of rice seeds after treatment with eco-enzyme and KNO3 soaking.

Treatment	KCT (% etmal)		
	1 MSP	2 MSP	3 MSP
K0 = $_{KNO3}$	49.38 ± 1.70 b	59.63 ± 1.93 a	63.63 ± 1.60 b
K1 = 0 %	49.00 ± 2.83 ab	61.75 ± 2.53 a	62.75 ± 2.87 bc
K2 = 5%	54.88 ± 1.44 a	63.38 ± 1.55 a	67.00 ± 1.41 a
K3 = 10%	53.50 ± 2.12 a	63.25 ± 2.60 a	61.75 ± 1.71 bc
K4 = 15%	53.13 ± 1.49 a	60.38 ± 2.78 a	59.75 ± 1.55 c
K5 = 20%	45.75 ± 3.33 c	53.88 ± 2.59 b	51.25 ± 3.30 d
W = Soaking Time			
W1 = 24 Hours	47.71 ± 3.00 b	55.96 ± 2.99 b	59.08 ± 3.43 b
W2 = 48 Hours	54.17 ± 5.03 a	64.79 ± 5.63 a	62.96 ± 7.56 a
K0W1	47.75 ± 1.89 de	52.25 ± 3.59 f	62.25 ± 3.40 bcd
K1W1	42.75 ± 5.91 e	54.25 ± 4.35 ef	59.50 ± 1.91 cd
K2W1	51.25 ± 3.30 bcd	60.00 ± 2.16 cd	63.25 ± 2.87 bc
K3W1	49.00 ± 2.94 cde	58.25 ± 1.26 de	57.75 ± 2.99 de
K4W1	49.50 ± 3.11 cd	57.25 ± 4.27 def	58.00 ± 3.16 de
K5W1	46.00 ± 5.35 de	53.75 ± 2.87 ef	53.75 ± 2.75 e
K0W2	51.00 ± 4.97 bcd	67.00 ± 2.58 ab	65.00 ± 0.82 b
K1W2	55.25 ± 0.50 abc	69.25 ± 1.71 a	66.00 ± 4.32 b
K2W2	58.50 ± 5.45 a	66.75 ± 4.19 ab	70.75 ± 1.26 a
K3W2	58.00 ± 4.08 a	68.25 ± 4.11 ab	65.75 ± 1.71 b
K4W2	56.75 ± 3.77 ab	63.50 ± 1.73 bc	61.50 ± 3.32 bcd
K5W2	45.50 ± 2.52 de	54.00 ± 2.94 ef	48.75 ± 3.95 f

Description: Numbers followed by different letters in the same treatment group are significantly different at the 5% level based on the DMRT test, while those without annotations indicate no significant difference.

3.2.6. Growth Simultaneity (%)

Eco-enzyme treatment and soaking time significantly affected the simultaneity of seed growth at 1 MSP, but did not significantly affect seed growth at 2 and 3 MSP. Data from the further test results on simultaneity of growth can be seen in Table 9.

Table 9. Simultaneity of rice seed growth after treatment with eco-enzyme and KNO3 soaking.

Treatment	Growth Simultaneity (%)		
	1 MSP	2 MSP	3 MSP
K0 = $_{KNO3}$	70.13 ± 2.95 b	83.25 ± 3.62 b	91.13 ± 1.80 a
K1 = 0 %	71.00 ± 4.42 b	84.75 ± 2.06 b	86.75 ± 3.10 b
K2 = 5%	79.75 ± 2.22 a	90.50 ± 1.78 a	92.75 ± 1.44 a
K3 = 10%	82.75 ± 1.76 a	89.25 ± 0.65 a	91.00 ± 1.35 a
K4 = 15%	81.63 ± 2.17 a	90.25 ± 1.94 a	91.25 ± 0.87 a
K5 = 20%	79.13 ± 3.09 a	84.50 ± 1.96 b	85.63 ± 3.99 b
W = Soaking Time			
W1 = 24 Hours	74.25 ± 6.26 b	83.79 ± 4.41 b	89.58 ± 1.62 ns
W2 = 48 Hours	80.54 ± 5.83 a	90.38 ± 3.14 a	89.92 ± 4.59 ns
K0W1	69.25 ± 3.30 de	77.00 ± 6.68 ns	92.00 ± 4.83 ns
K1W1	64.25 ± 9.74 e	80.25 ± 5.85 ns	88.00 ± 3.74 ns
K2W1	74.75 ± 1.50 cd	88.00 ± 4.08 ns	90.75 ± 3.59 ns
K3W1	79.25 ± 2.22 abc	85.50 ± 2.65 ns	88.75 ± 3.40 ns
K4W1	78.50 ± 2.52 bc	88.00 ± 2.94 ns	90.00 ± 2.58 ns
K5W1	79.50 ± 5.80 abc	84.00 ± 3.74 ns	88.00 ± 3.46 ns
K0W2	71.00 ± 5.72 d	89.50 ± 2.89 ns	90.25 ± 1.71 ns
K1W2	77.75 ± 1.71 bc	89.25 ± 2.75 ns	85.50 ± 2.65 ns
K2W2	84.75 ± 4.50 ab	93.00 ± 1.83 ns	94.75 ± 1.26 ns
K3W2	86.25 ± 4.03 a	93.00 ± 1.41 ns	93.25 ± 2.22 ns
K4W2	84.75 ± 2.63 ab	92.50 ± 1.91 ns	92.50 ± 3.11 ns
K5W2	78.75 ± 1.71 bc	85.00 ± 0.82 ns	83.25 ± 6.65 ns

Description: Numbers followed by different letters in the same treatment group are significantly different at the 5% level based on the DMRT test, while those without annotations indicate no significant difference.

The administration of eco-enzymes with concentrations of K3, K4, and K5, along with a soaking

period of 24 hours to 1 MSP seeds, significantly increased the simultaneity of rice seed growth compared to the administration of KNO3. However, the response was not significantly different from KNO3 in the K2 treatment. Similar treatments did not provide significant differences between 2 and 3 MSP seeds.

At 48 hours of soaking time, eco-enzyme at all concentration levels significantly increased the growth simultaneity compared to KNO3 for 1 MSP seed. The 48-hour soaking time treatment significantly increased the growth simultaneity compared to 24 hours of soaking time for seeds tested at 1 MSP and 2 MSP but was not significantly different at 3 MSP.

The simultaneity of growth and the speed of seed growth are indicators of superior seed quality, where superior seeds with high vigor can be identified based on their high simultaneity of growth and growth speed. Based on the study's results, it was found that the highest speed and simultaneity of growth were achieved in the K2W2 treatment. At 3 MSP, the growth speed reached 70.75%, and the simultaneity of growth in these rice seeds was 94.75%. The simultaneity of growth value is relatively high, indicating that the potential for seed growth will also be high. This result aligns with Ashar et al.'s (2024) assertion that synchronous and high seed growth indicate high growth strength. It is because the group of seeds that show synchronous and strong growth shows high vigor.

Here are some pictures that show the differences in seed results with several treatments:

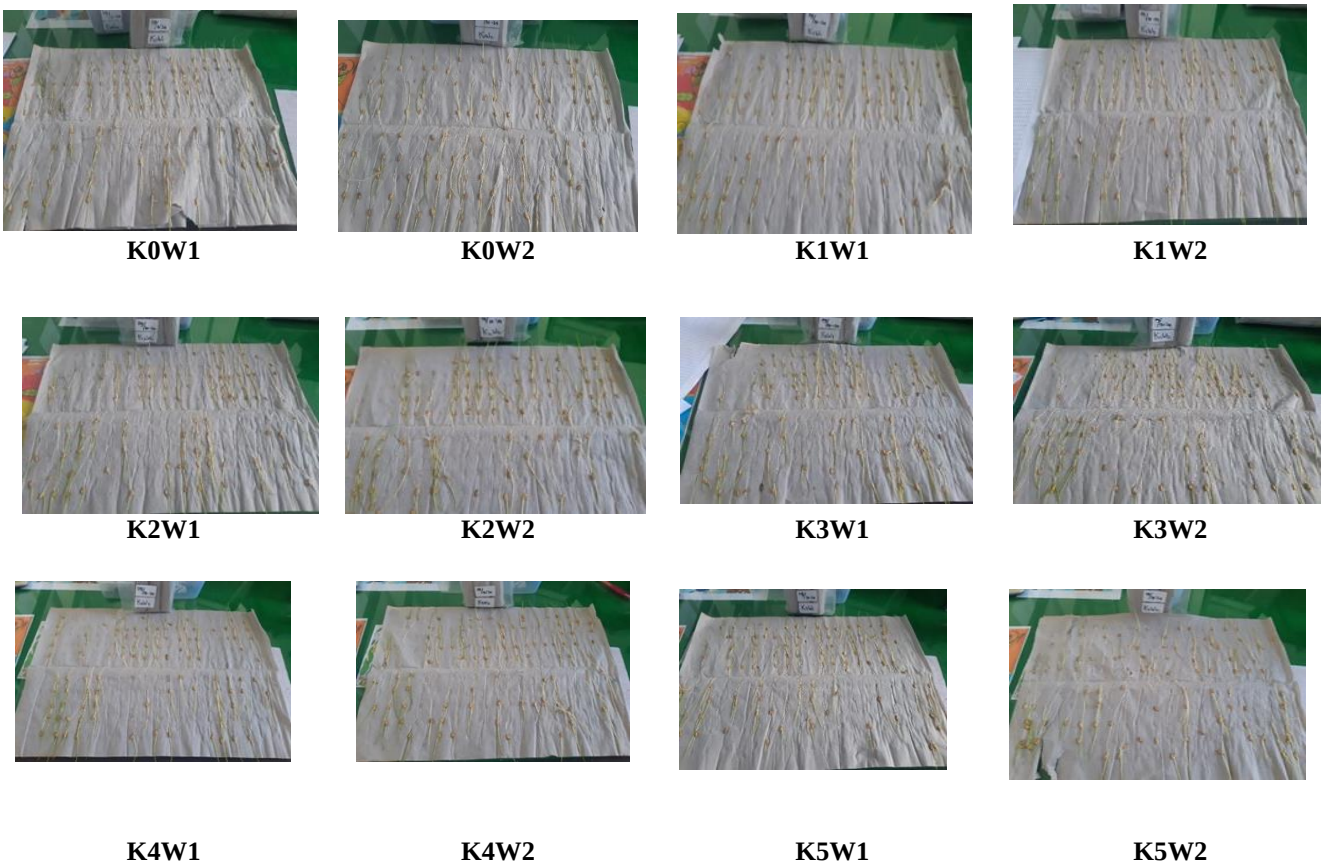

Figure 2. The differences in seed results with several treatments

4. Conclusion

The best treatment for breaking dormancy in 1 MSP Inpari 32 HDB rice seeds is soaking with eco-enzyme at a concentration of 15% for 48 hours. The best treatment for breaking dormancy in 2 MSP and 3 MSP Inpari 32 HDB rice seeds is soaking with eco-enzyme at a concentration of 5% for 48 hours. Eco-enzymes with concentrations of 5%, 10%, and 15% have the potential to break the dormancy of Inpari 32 HDB rice seeds, replacing KNO3 at 0.2%.

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