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Response of several local gogo paddy varieties at different potassium nitrate concentrations to breaking seed dormancy

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ABSTRACT

Rice cultivation is often faced with land availability problems, especially paddy fields, which require special irrigation. Rice cultivation in dry land is called gogo paddy or paddy field. Efforts to increase rice production using gogo paddy have great potential to be developed to overcome obstacles in the availability of paddy fields. Gogo Paddy cultivation is often faced with seed dormancy problems, where the seeds are unable to germinate so that it takes a long time for dormancy to break and consequently it is difficult to get uniform growth. This study aims to examine the Effect of kalium nitrat (KNO_3 Concentration to breaking dormancy on Several Local Gogo paddy Varieties in North Sumatra. The experiment was carried out at the laboratory of North Sumatra Food Crops and Horticulture Seed Certification center from March 2025 to May 2025. This study uses a Factorial Complete Random Design (CRD). The first are consisting of local Gogo paddy variety factors, namely; V1 (Si Kambiri Lumat), V2 (Si Dampal), V3 (Si Ponu) and V4 (Si Lombu) and the KNO_3 Concentration namely; K0(control), K1(1%), K2 (2%) and K3(3%) The observations made are on the Radicule Length, Plumula Length, Normal Sprout Number, Germination Power Percentage, Dry Weight of the sprout. The results of the study show KNO_3 treatment (3% concentration) had an effect on the variables of radicule length, plumula length, normal germination count, germination percentage and dry weight of sprouts and that the difference in varieties has a real effect on the breakage of seed dormancy, the variety that shows the best influence is the Dampal variety.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cultivated crops in human civilization and serves as the main source of carbohydrates for a large portion of the world's population. As a staple food crop, rice production plays a central role in global food security, especially in Asia where it accounts for the majority of calories consumed (Food and Agriculture Organization of the United Nations, n.d.; Sattari et al., 2008). In many countries, rice production is traditionally derived from paddy fields; however, the area of rice fields has been decreasing in recent years due to the conversion of agricultural land into industrial uses and urban settlements, which poses challenges for continued rice production and availability (Widiwurjani, Nugroho, & Kurniawan, 2021). North Sumatra Province as a rice producer in the country will be programmed to become a national rice barn, considering that rice production in the area is quite large. This is supported by five districts that have been known as the largest rice-producing centers in North Sumatra, namely Deli Serdang, Serdang Bedagai, Langkat, Labuhan Batu Utara and Mandailing Natal (Madina) (Tarigan et al., 2013).

According to BPS North Sumatra (2023), rice production in North Sumatra in 2022 reached 2.09 million tons of Milled Dry Rice (GKG) with a planting area of 411.46 thousand hectares and decreased in 2023 where the production of 2.08 million tons of GKG from a planting area of 406.11 thousand hectares. The decrease in the planting area is due to the fact that many rice fields are planted depending on climatic conditions that are worsening with floods and droughts. There are two types of rice cultivation that are widely carried out in Indonesia, namely paddy rice and gogo paddy. Paddy is rice cultivation on rice fields or wetlands. In addition to being planted in rice fields, rice can also be cultivated on dry land. Rice cultivation in dry land is called gogo paddy.

Efforts to increase rice production using paddy gogo have great potential to be developed to overcome obstacles in the availability of rice fields. Gogo Paddy in this study uses the type of gogo paddy of the local varieties of North Sumatra, namely the Si kambiri lumat variety, the Si Dampal variety, the Si Ponu variety and the Si Lombu variety. The propagation material used in gogo paddy is the seeds. Rice cultivation is often faced with seed dormancy problems so that it takes a long time for dormancy to break and consequently it is difficult to get uniform growth. The cause of this seed dormancy is due to the harder condition of the rice seed skin so that it is difficult for water and air to penetrate. Hard seed skin can affect the viability and vigor of seeds to germinate meaning that the ability of seeds to germinate under certain environmental conditions becomes less optimal and seed performance during germination and seedling growth becomes low, resulting in decreased seed quality. Efforts to shorten the dormancy period can be done in various ways, including in the form of providing physical, mechanical, and chemical treatments.

Soaking seeds in chemical solutions such as KNO_3 or sulfuric acid has been shown to help break dormancy by softening or increasing the permeability of seed shells so that water enters more easily and the imbibition process takes place faster (Wijaya et al., 2024; Sipahutar et al., 2023; Suyatmi et al., 2011). Potassium nitrate (KNO_3) is a compound that is commonly used to break seed dormancy and is able to stimulate seed germination. KNO_3 can affect respiration directly. KNO_3 is also able to increase the seeds against light (Copeland and McDonald, 2001). The characteristics of KNO_3 solution are relatively economical, safe and easy to use, scientific research on dormancy fracturing using the solution. The method of breaking the dormancy of rice seeds according to ISTA (2010), According to Candra, *et al*, (2017), research on pomegranate seeds stated that the application of KNO_3 at a concentration of 0.3% gave germination results of 80% and a Vigor Index of 1.48.

The soaking treatment of KNO_3 solution in rice plants had a significant influence on the observation parameters of radicule length and leaf count at the age of 21 HST (Rahmatika *et al*., 2020). Yucel and Yilmaz (2009), added that a low concentration (0.5%, 1%) of KNO_3 solution can increase the germination percentage of *salvia cyanescans plant seeds.*

2. METHOD

The research was carried out at the North Sumatra Food and Horticulture Seed Certification center Unit Laboratory from March 2025 to May 2025. This research was carried out by germinating seeds on paper, The paper method is rolled with a number of 100 grains of rice seeds each treatment at germination room temperature (25-30^{0}C) under dark light conditions. the research used a Factorial Complete Random Design (CRD) with 2 treatment factors.

The first factor is, the Concentration of Potassium Nitrate (KNO_3) Solution which consists of 4 levels of treatment: K0: 0 % (without treatment), K1: 1% (10 g/1000 ml water), K2: 2% (20 g/1000 ml water), K3: 3% (30 g/1000 ml water). The second factor is the local gogo paddy Variety, consisting of 4 varieties, namely: V1: Si Kambiri Lumat, V2: Si Dampal, V3: Si Ponu, V4: Si Lombu

2.1 Observation Variables

2.1.1 Radicula Length (cm)

The length of the radicule was calculated to 100% of the radicule grew in each treatment from the age of 2, 4, 6, 8 DAS (Day After Sowing).

2.1.2 Plumula Length (cm)

The length of the plumula was calculated to 100% of the radicula grown in each treatment from the age of 2 , 4, 6, 8 DAS (Day After Sowing).

2.1.3 Normal Sprout Count (sprouts)

The number of normal live sprouts is carried out at the age of 8 DAS (Day After Sowing).

2.1.4 Germination Percentage (%).

The germination percentage of pas carried out on day 6 (1st observation) and day 8 (2nd observation).

Germination Percentage Formula:

$$\text{Germination Percentage (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds tested}} \times 100 \quad (1)$$

2.1.5 Normal Sprout Dry Weight (g)

Normal sprout dry weight was measured on the last day of observation, i.e. after being in the oven at 60°C for 3x24 hours after 8 DAS. The sprouts are then put in a desiccant ± 30 minutes. Dried sprouts are weighed on a four-digit scale. The weight obtained is divided by the number of normal sprouts that are ovened.

3. RESULTS AND DISCUSSION

3.1 Radicula Length (cm)

Based on data and results of various fingerprints, the treatment of different varieties and concentrations of KNO3 and their interactions showed a real influence on the observation of 2 Day After Showing (DAS) to 8 DAS. The results of the test on the difference in the average influence of Variety and concentration of KNO_3 and its interaction on the Radicular Length of age 2, 4, 6, 8 DAS can be seen in Table 1 below:

Table 1. Average Difference test effect of Varieties and the concentration of KNO_3 on the Radicular Length at the age of 2, 4, 6, 8 DAS

Variables	Radicular length at the age			
	2 DAS	4 DAS	6 DAS	8 DAS
Varieties				
V1	0,25 b	1,33 c	4,10 c	6,48 b
V2	2,47 a	5,51 ab	11,00 a	15,62 a
V3	2,56 a	6,75 a	10,63 a	14,88 a
V4	0,88 b	4,71 b	7,60 b	14,41 a
KNO3 Concentration				
K0	0.07c	2.96 b	6.62 c	9.36 c
K1	1.75 b	3.78 b	8.55 b	13.08 b
K2	2.06 ab	5.70 a	8.87 b	14.14 ab
K3	2.28 a	5.82 a	9.29 a	14.81 a
VxK Interaction				
V1K0	0.13 d	1.04 g	2.17 e	3.11 i
V1K1	0.25 d	1.45 g	5.86 d	8.11 g
V1K2	0.25 d	1.43 g	4.13 d	5.80 h
V1K3	0.38 d	1.38 g	4.22 d	8.89 fg
V2K0	0.13 d	1.63 g	6.17 d	11.32 de
V2K1	0.76 d	1.80 g	8.75 c	16.87 ab
V2K2	4.56 a	8.45 b	16.20 a	18.53 a
V2K3	4.42 a	10.15 a	12.87 b	15.77 bc
V3K0	0.00 d	5.90 d	9.49 c	12.67 cd
V3K1	3.51 ab	6.93 c	9.69 c	12.68 cd
V3K2	3.43 b	8.35 b	9.80 c	15.80 bc
V3K3	3.30 bc	5.45 d	13.55 b	18.35 a
V4K0	0.00 d	3.25 f	8.63 c	10.32 ef
V4K1	2.48 c	4.96 de	9.88 c	14.65 c
V4K2	0.00 d	4.36 e	5.36 d	16.44 bc
V4K3	1.03 d	6.28 cd	6.52 d	16.22 bc

Noted: The same letters in the same colomn was shown indiffrently (HSD 5%)

From Table 1, the treatment of different varieties showed that the highest radicle length was obtained in the V2 variety (Si Dampal), while the KNO_3 concentration treatment resulted in the highest radicle length at K3 (3%). The interaction between variety and KNO_3 concentration indicated that the combination of V2K2 (Si Dampal with 2% KNO_3) produced the greatest radicle length. This response suggests that radicle elongation during early germination is influenced by the interaction between varietal genetic potential and appropriate KNO_3 concentration. Nitrate supplied through KNO_3 acts as a physiological signal that stimulates metabolic activity, enhances respiration, and promotes early root growth, thereby supporting radicle elongation (Alboresi et al., 2005). In addition, water imbibition during seed soaking increases cell wall permeability, facilitating oxygen diffusion into the embryo and improving respiratory activity of living cells, which ultimately accelerates embryo growth and radicle extension (Nonogaki et al., 2010).

3.2 Plumula Length (cm)

Based on the data from the results of various fingerprints at the age of 4, 6, 8 DAS the variety and concentration of KNO_3 show a real influence on the length of the plumula and its interaction shows an unreal effect on the age of 4 DAS and a real effect on the age of 6 and 8 DAS. The results of the test of the difference in the average influence of varieties and concentrations of KNO_3 and its interaction on the length of the 4, 6, and 8 DAS plummies can be seen in Table 2 below:

Table 2. Average difference test of the effect of The Varieties and Concentration of KNO_3 on the length of the plumule at 4, 6, 8 DAS.

Variables	Length of Plumule		
	4 DAS	6 DAS	8 DAS
Varieties			
V1	1.98 b	5.05 c	4.62 c
V2	2.97 a	6.44 c	6.12 b
V3	1.96 b	7.39 b	6.92 b
V4	1.82 b	8.86 a	8.92 a
KNO3 Concentration			
K0	1.69 b	5.05 c	4.62 c
K1	1.37 b	6.44 c	6.12 cb
K2	1.76 a	7.39 b	6.92 b
K3	1.81 a	8.86 a	8.92 a
VxK Interaction			
V1K0	0.08	1.79 h	1.72 j
V1K1	2.83	1.71 h	2.53 i
V1K2	2.16	1.64 h	3.89 h
V1K3	2.83	1.96 h	7.22 d
V2K0	1.70	8.29 e	7.31 cd
V2K1	2.25	9.57 c	8.81 b
V2K2	2.20	10.79 b	8.89 b
V2K3	2.46	11.86 a	10.03 a
V3K0	2.18	5.43 g	5.00 g
V3K1	1.53	7.57 ef	6.61 ef
V3K2	1.86	9.00 cd	7.78 c
V3K3	2.38	11.11 ab	9.72 a
V4K0	8.58	4.71 g	4.44 gh
V4K1	1.58	6.89 f	6.53 f
V4K2	2.73	8.14 e	7.11 de
V4K3	2.13	10.50 c	8.72 b

Noted: The same letters in the same colomn was shown indiffrently (HSD 5%)

From Table 2 above, the varietal treatment showed that the highest plumule length was obtained in V2 (Si Dampal), while the KNO_3 concentration treatment resulted in the highest plumule length at K3 (3%). The interaction between variety and KNO_3 concentration indicated that the combination of V2K3 (Si Dampal with 3% KNO_3) produced the greatest plumule length. In rice (*Oryza sativa*), plumule elongation during early seedling growth is closely associated with enhanced metabolic activity and cell elongation in shoot tissues. Nitrate supplied through KNO_3 acts as a regulatory signal that promotes seedling growth by stimulating cellular metabolism and supporting shoot development during early germination stages (Alboresi et al., 2005). In addition, early shoot elongation in rice seedlings is strongly regulated by gibberellin-mediated cell elongation, which is activated following water imbibition and reserve mobilization during germination, leading to increased plumule growth (Yamaguchi, 2008). Furthermore, vigorous plumule growth in upland rice is closely associated with efficient mobilization of seed reserves and active cell elongation in shoot tissues, which enable seedlings to establish rapidly under non-flooded conditions (Farooq et al., 2009).

3.3 Normal Sprout Count (Germination)

Based on the data of the fingerprint results of various varieties and the concentration of KNO_3 and Varieties and their interactions, it shows a real influence on the number of normal sprouts aged 8 DAS. The results of the test showed the difference in the average influence of varieties and the concentration of KNO_3 on the normal number of sprouts aged 8 DAS in Table 3 below.

Table 3. Average difference test of the effect of the varieties and concentration of KNO_3 on the number of normal sprouts aged 8 DAS

KNO3 Concentration	Varieties				Average
	V1	V2	V3	V4	
K0	15.00 m	65.00 ef	45.00 i	40.00 j	41, 25 d
K1	25,00 l	74.00 p	60.00 g	55.00 h	53.5 c
K2	35.00 k	80.00 c	70,00 e	65.00 f	62.5 b
K3	65.0 f	90 .00 a	84.75 b	81.00 c	80.19 a
Average	35.00 d	77, 25 a	64, 94 b	60, 25 c	

Noted: The same letters in the same colomn was shown indiffrently (HSD 5%)

From Table 3 above, the varietal treatment showed that the highest number of normal seedlings was obtained in V2 (Si Dampal), while the KNO_3 concentration treatment resulted in the highest number of normal seedlings at K3 (3%). The interaction between variety and KNO_3 concentration indicated that the combination of V2K3 (Si Dampal with 3% KNO_3) produced the highest number of normal seedlings. This result indicates that the formation of normal seedlings is strongly influenced by the interaction between varietal genetic potential and nitrate availability. In upland rice, normal seedling development reflects high seed vigor and balanced growth of radicle and plumule, which are essential for successful establishment under aerobic conditions. Nitrate supplied through KNO_3 enhances early metabolic activity, stimulates enzyme activation, and supports coordinated root and shoot development during germination, thereby increasing the proportion of normal seedlings (Alboresi et al., 2005; Nonogaki et al., 2010).

3.4 Seed Germination Percentage (%)

Based on the data of the various fingerprint results, the type and concentration of KNO_3 and the interaction of the two treatments showed a real influence on the percentage of seed germination percentage in observations 6 and 8 DAS. The results of the test of the difference in the average influence of variety and KNO_3 concentration on the percentage of seed germination (%) of age 6 and 8 DAS can be seen in Table 4 below:

Table 4. Average difference test of the effect The variety and KNO_3 Concentration on the seed germination percentage (%) age 6 and 8 DAS

Variables	The percentage plant germination (%)	
	6 DAP	8 DAP
Varieties		
V1	19.8 c	44.0 c
V2	68.1 b	80.3 b
V3	80.0 a	90.6 a
V4	53.1 b	76.0 b
KNO3 Concentration		
K0	52.3	66.1 c
K1	52.7	75.6 b
K2	74.3	74.3 b
K3	81.7	83.4 a
VxK Interaction		
V1K0	31.1 ef	21.7 hi
V1K1	11.8 f	32.8 gh
V1K2	14.3 ef	56.9 h
V1K3	22.2 ef	64.7 f
V2K0	27.9 ef	61.7 f
V2K1	40.7 ef	73.9 cd
V2K2	72.5 b-e	88.6 b
V2K3	89.4 ab	99.8 a
V3K0	90.7 abc	94.9 ab
V3K1	90.8 ab	96.9 ab
V3K2	96.67 a	98.0 ab
V3K3	85.4 abc	96.1 ab
V4K0	32.5 ef	86.3 bc
V4K1	49.6 def	98.8 ab
V4K2	67.5 c-f	53.6 h
V4K3	62.8 c-f	65.2 f

Noted: The same letters in the same colomn was shown indiffrently (HSD 5%)

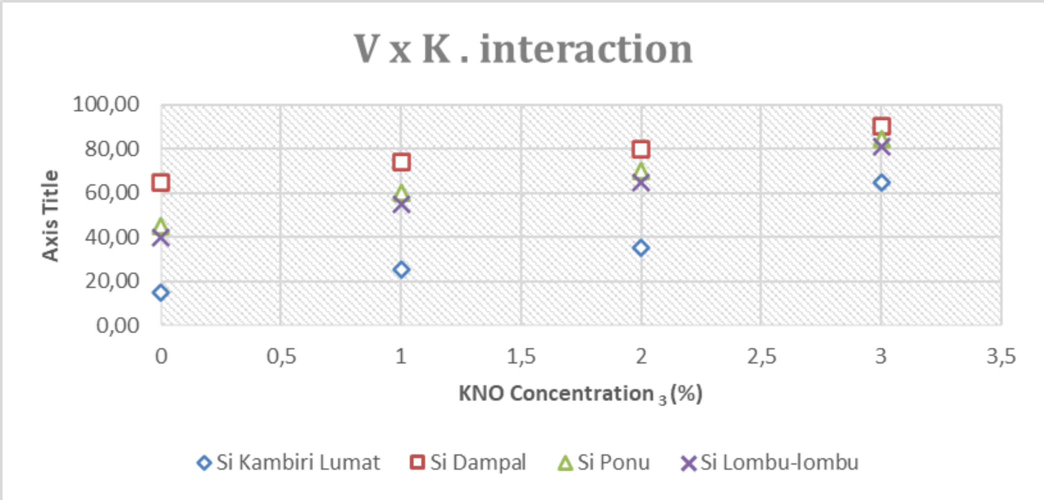

Figure 1. Interaction Curve of KNO_3 Concentration and Varieties to the Number of Normal Sprouts age 8 DAS.

From Table 4 above, the highest amount of germination power is found in the treatment of the V3 variety (Si Pono) and the concentration of KNO_3, namely K3 (3%). The interaction of variety and concentration of KNO_3 showed that the highest germination percentage in the observation of 6 DAS was found in the combination of V3K2 (Si Ponu and KNO_3 2%), while in the observation of 8 DAS was found in the combination of V2K3 (Si Dampal and the concentration of KNO_3 3%). This suggests that germination success is influenced by the interaction between the genetic potential of the variety and the concentration of KNO_3 given. Nitrate from KNO_3 acts as a physiological signal that can spur metabolic activity and accelerate the breakdown of seed dormancy in the early phase of germination (Alboresi et al., 2005). The success of germination is also closely related to the availability of adequate water, because the process of water imbibition triggers enzyme activation, respiration, and cell elongation in the sprout. Suitable environmental conditions allow physiological and biochemical processes to take place optimally during the germination phase (Nonogaki et al., 2010). In addition, the interaction between the genetic factors of the variety and the growing environment, including the availability of nutrients, plays an important role in expressing the plant's early growth potential. Without proper environmental management, the superior potential of a variety is difficult to achieve optimally (Ceccarelli et al., 1992; Blum, 2011).

Figure 1 shows that the highest number of sprouts was in the combination of treatment of the Si dampal variety with a concentration of KNO3 of 3%. The highest number of sprouts was obtained in which suggests that this variety has a strong physiological response to increased nitrate concentrations in spurring the germination process. Higher concentrations of KNO_3 provide sufficient amounts of nitrate ions (NO_3^-) to act as metabolic triggers and germination signals, which effectively suppress the activity of the hormone abscisic acid (ABA) and increase the role of gibberellin (GA), thereby accelerating germination initiation and increasing the number of seeds capable of germinating (Bewley et al., 2013; Baskin & Baskin, 2014). In the Si Dampal variety, an increase in nitrate availability at a concentration of 3% is thought to be able to overcome stronger physiological dormancy in some seeds, so that the percentage and number of sprouts increase compared to the lower concentration. In addition, nitrates are known to increase early respiration and enzymatic activity related to the mobilization of food reserves, so that more embryos successfully resume growth into normal sprouts (Copeland & McDonald, 2001). Nevertheless, although a concentration of KNO_3 of 3% is effective in increasing germination count, this response is not always followed by an optimal increase in germination growth, since at high concentrations of nitrates can lead to an increase in osmotic pressure that potentially limits biomass accumulation, so the effectiveness of KNO_3 is highly dependent on the purpose of the test, whether to maximize germination numbers or the quality of initial growth (Taiz et al., 2015; ISTA, 2023).

3.5 Normal Sprout Dry Weight (g)

Based on the data of the variety of varieties and concentrations and their interactions, it shows an unreal effect on the dry weight of sprouts aged 8 HST. The results of the test of the difference in the average effect of variety and concentration of KNO_3 on the dry weight of sprouts (g) aged 8 DAS can be seen in Table 5 below.

Table 5. Average difference test of the effect of the variety and KNO3 Concentration on the dry weight of sprouts (g) age 8 DAS.

KNO3. Focus Solution	Varieties				Average
	V1	V2	V3	V4	
K_0	17.02	37,46	37,44	33.09	31.25
K_1	25,56	54,56	36.91	38.66	38.92
K_2	29,15	46,49	52.65	55.01	45.83
K_3	27.90	54.44	48.33	50.32	45.25
Flattening	17.02	37,46	37,44	33.09	31.25

Remark: DAS= Day After Showing

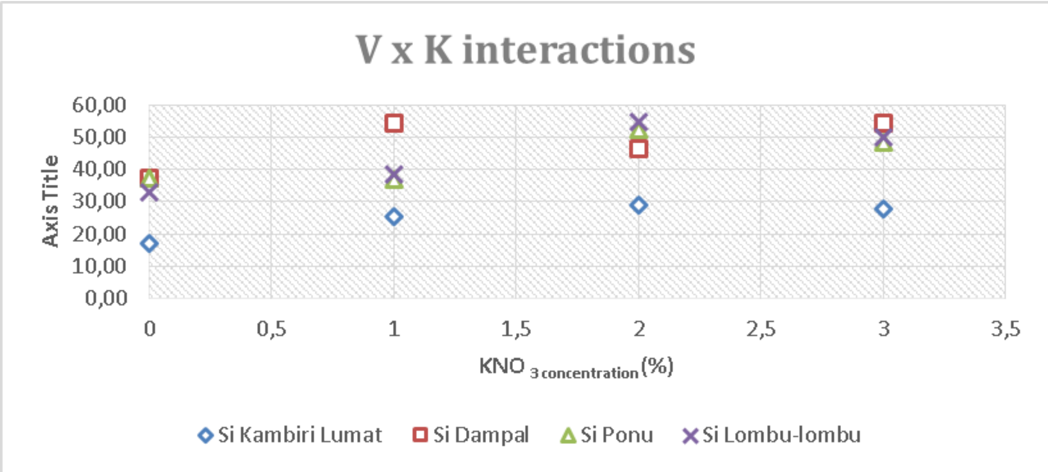

Figure 2. Interaction Curve of KNO_3 Concentration and Varieties on Dry Weight normal sprouts aged 8 DAS

From Table 5 above, it shows that the heaviest dry weight is found in the treatment of the V2 variety (Si Dampal) and the concentration of KNO_3 in K2 (2%). The interaction of variety and concentration of KNO_3 with dry weight was highest in the combination of V4K2 (Si Lombu and 2% concentration of KNO_3).

Figure 2. It showed that the Si Dampal paddy gogo varieties with the highest normal germination dry weight at the KNO_3 1% treatment, which indicates that the concentration is most effective in breaking seed dormancy and increasing germination vigor. Nitrate ions (NO_3^-) from KNO_3 act as physiological signals that suppress the influence of germination-inhibiting hormones, especially abscisic acid (ABA), while increasing the activity of gibberellin (GA) thereby stimulating the synthesis of hydrolytic enzymes such as α-amylase which accelerate the breakdown of endosperm starch reserves into energy sources for germination growth (Bewley et al., 2013; Baskin & Baskin, 2014). In addition, K^+ ions support enzyme activation and cell osmotic balance which plays a role in cell division and elongation during the initial phase of germination, resulting in increased germination biomass accumulation (Taiz et al., 2015). The concentration of KNO_3 1% was considered to be at the optimal level to stimulate metabolic processes without causing osmotic stress, which is reflected in the increase in the dry weight of normal sprouts as an indicator of the success of the fracture of physiological dormancy in the seeds of gogo rice of the Si Dampal variety (Copeland & McDonald, 2001). According to Halimursyadah et al. (2020), potassium nitrate (KNO_3) had a very significant effect on germination and the dry weight of normal seedlings, as well as significant effects on maximum growth potential and relative growth rate in several organic mutant rice lines after ripening, demonstrating its effectiveness in breaking physiological dormancy and enhancing early seedling development.

4. CONCLUSION

Differences among rice varieties significantly influenced dormancy breaking, with the Dampal variety showing the best response. Potassium nitrate (KNO_3) concentration significantly affected radicle length, plumule length, number of normal seedlings, germination percentage, and dry weight of normal seedlings. In addition, the interaction between variety and KNO_3 concentration significantly influenced dormancy breaking, as indicated by effects on radicle length, plumule length, number of normal seedlings, and germination percentage, indicating that varietal characteristics determine the effectiveness of KNO_3 application in enhancing rice seed germination.

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