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Improvement of Seed Viability and Vigor of Several Rice Varieties with Various Priming Methods

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Abstract

Rice serves as Indonesia's main food source, but inadequate storage conditions can lead to seed deterioration and diminished germination performance. To enhance the viability and vigor of stored seeds, this study explores various priming methods' effects on multiple rice varieties. Employing a completely randomized design (CRD) with two factors, the first factor involves rice varieties (V) categorized by germination ranges: 41–50% (V1 = Toyonishiki, V2 = Yoneshiro), 51–60% (V3 = Jaya, V4 = IR50), 61–70% (V5 = Fortuna, V6 = Sulutan), and 71–80% (V7 = IR 24, V8 = Inpago 5). The second factor is seed priming (P), including control, hydropriming, and osmopriming. Results indicate that priming enhances maximum growth potential, germination percentage, vigor index, growth speed, plumule and radicle length, as well as fresh and dry weight. Hydropriming outperforms osmopriming, particularly in vigor index, growth speed, plumule and radicle length, and dry weight. Priming proves more effective in improving maximum growth potential, germination percentage, vigor index, and growth speed at lower germination percentage ranges (41–60%). The most significant priming-induced increases in radicle length, fresh weight, and dry weight occur in higher germination percentage ranges (61–80%)

Keywords : Deterioration; Priming; Rice Seed; Viability; Vigor

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1. Introduction

Rice (*Oryza sativa*), a staple food, is consumed and 90% produced in Asia, serving as the main food source for the majority of Indonesia's population [1], [2]. To fulfill the national rice demand, high-quality seeds are essential for ensuring high crop production. Indonesia's hot and humid tropical climate, coupled with inadequate storage conditions, accelerates seed deterioration [3], leading to reduced quality, viability, and vigor through natural aging or improper storage [4]. Farmers in swampland, facing resource limitations, often resort to low-quality seeds, resulting in unhealthy seedlings and low productivity [5]. Priming emerges as a solution to restore the quality of deteriorated seeds, addressing this challenge.

Seed priming is a treatment that enhances the viability and vigor of low-quality seeds [6]. It involves hydrating the seed to activate pre-germination metabolism before radicle emergence [7]. Various priming techniques, such as hydropriming and osmopriming, exist. Hydropriming entails soaking seeds in unaerated water [8], offering an affordable and cost-effective method to break seed dormancy and boost germination [9]. Ibrahim et al.'s (2013) study demonstrated that hydropriming increased germination percentage and accelerated rice seed germination.

Osmopriming involves soaking seeds in a salt solution or PEG [8]. PEG (Polyethylene glycol), a water-soluble natural polymer, gradually reduces water potential, facilitating imbibition into the seed [10]. Osmopriming with PEG 6000 increased germination and seed vigor in several plants, such as wheat (*Triticum aestivum* L.) [11], corn (*Zea mays* L.) [12], peas (*Pisum sativum* L.) [13], soybean (*Glycine max* L.) [14], and Sorghum (*Sorghum bicolor L.*) [15]. Shereen et al.'s (2019) study found that PEG 6000 at 20% affected germination in over 50% and growth in over 80% of several rice genotypes [16].

Based on this description, hydropriming and osmopriming increase the germination ability of rice. Currently there is no research on priming to increase the viability and vigor of seeds with different germination percentage ranges. This study aims to determine the effect of various priming methods on increasing the viability and vigor of seeds of several rice varieties.

2. Materials and Methods

2.1 Materials

This research used nursery trays, erlenmeyer, measuring cups, measuring tape, and analytical scales. The materials used are distilled water, rice seeds, PEG 6000, and soil.

2.2 Experimental design and statistical

This research was conducted using a completely randomized design (CRD) with 2 factors. The first factor was rice variety (V), the seeds are germinated and grouped based on germination ranges, consisting of range 41 – 50% (V1 = Toyonishiki and V2 = Yoneshiro), range 51 – 60% (V3 = Jaya and V4 = IR50), range 61 – 70% (V5 = Fortuna and V6 = Sulutan), and range 71 – 80 % (V7 = IR 24 and V8 = Inpago 5). The second factor was seed priming (P), which consisted of P1 = Control, P2 = Hydropriming, and P3 = PEG 6000. This study consisted of 24 treatments with 3 replications, each consisting of 50 seeds.

The data obtained were analyzed using RStudio software version 1.14.1717 for Windows (developed by RStudio team, PBC, Boston, MA). To see the difference between treatments, tests were carried out using least significant difference (LSD) at $P \leq 0.05$.

2.3 Seed Priming

In the hydropriming treatment, the seeds were soaked in 100% distilled water. Osmopriming carried out by soaking the seeds in PEG 6000 20% (200g/l) [17] for 24 hours [18]. The seeds then washed and air-dried for 4 hours until they returned like pre-condition before priming [19].

2.4 Data Collection

2.4.1 Maximum Growth Potential (MGP) (%)

The maximum growth potential is obtained by calculating the number of seeds that germinate normally or abnormally at 7 DAP with the formula [20]:

$$MGP\ (\%) = \frac{\Sigma\ Germinate\ seeds}{\Sigma\ Planted\ seeds}\ x\ 100$$

2.4.2 Germination Percentage (GP) (%)

Germination percentage is obtained by calculating the number of seeds that germinate normally at 7 DAP with the formula [2]:

$$GP\ (\%) = \frac{\Sigma\ Germinate\ seeds\ at\ 7\ DAP}{\Sigma\ Planted\ seeds}\ x\ 100$$

2.4.3 Vigor Index (VI) (%)

Observation of the vigor index is obtained by calculating the number of normally germinate seeds at 5 DAP with the formula [2]:

$$VI\ (\%) = \frac{\Sigma\ Germinate\ seeds\ at\ 5\ DAP}{\Sigma\ Planted\ seeds}\ x\ 100$$

2.4.4 Growth Speed (GS) (%/etmal)

Growth speed is calculated on normally germinate seeds every day for 7 days with the formula [2]:

$$GS = \%\frac{Germinate\ seeds}{etmal} = \sum_{0}^{tn} \frac{N}{t}$$

t = time of observation
N = percentage of normal germinate seeds at each observation time
tn = end time of observation (day 7)
1 *etmal* = 1 day.

2.4.5 Plumule Length (PL) (cm)

After 7 days of germination, the length of the plumule was measured from the base of the stem to the tip of the plumula [21].

2.4.6 Radicle Length (RL) (cm)

After 7 days of germination, the length of the radicle was measured from the base of the root to the tip of the root [21].

2.4.7 Fresh Weight (FW) (mg)

After 7 days, the fresh weight of the normally germinate seeds was weighed on analytical balance.

2.4.8 Dry Weight (DW) (mg)

After 7 days, normally germinate seeds were dried in an oven at 60°C for 72 hours, then weighed using analytical balance [2].

3. Results and Discussion

The diversity analysis results indicated a highly significant impact of rice varieties and priming, with their interaction notably influencing plumula length (Table 2). Germination percentage assesses seed capability under optimal conditions [22]. Yoneshiro, within the higher germination percentage range, outperformed Toyonishiki in vigor index, growth speed, plumule length, radicle length, fresh weight, and dry weight (Table 1). Jaya exhibited superior germination percentage, plumule length, fresh weight, and dry weight compared to IR 50. Sulutan demonstrated higher maximum growth potential, germination percentage, vigor index, growth speed, radicle length, and fresh weight than Fortuna. Inpago 5 displayed superior germination performance, significantly differing from IR 24 across all germination variables. In their respective germination groups, Yoneshiro, Jaya, Sulutan, and Inpago 5 stood out as the best varieties.

Table 1. Effect of priming on seed viability and vigor of various rice varieties.

	MGP (%)	GP (%)	VI (%)	GS (%/etmal)	PL (cm)	RL (cm)	FW (mg)	DW (mg)
				Rice Varieties				
Toyonishiki	56,44 a	54,67 a	52,67 a	12,34 a	7,15 abcde	7,84 a	52,34 a	9,31 abc
Yoneshiro	54,67 a	54,22 a	52,89 ab	14,33 ab	7,29 abcdef	8,39 ab	54,62 a	11,89 e
Jaya	65,11 b	65,11 b	60,22 bc	15,44 bc	7,47 bcdef	8,54 abc	75,71 e	12,22 e
IR 50	65,78 b	64,89 b	78,44 bc	16,81 bc	6,94 abc	11,37 e	65,48 bcd	9,12 a
Fortuna	75,33 c	75,11 c	69,56 d	21,52 e	6,71 a	8,98 bc	61,53 b	10,20 bcd
Sulutan	77,78 cd	77,56 cd	71,33 d	19,36 d	6,85 ab	11,24 e	66,79 bcd	9,64 abcd
IR 24	79,33 cd	78,89 cd	56,89 e	23,71 f	6,97 abcd	9,60 d	65,28 c	9,15 ab
Inpago 5	88,44 e	87,56 e	84,44 f	26,27 g	10,69 g	14,46 f	108,11 f	15,63 f
LSD.05	6,28	6,68	6,87	2,09	0,68	0,84	6,71	1,08
				Priming				
Control	58,17 a	57,58 a	53,75 a	10,79 a	5,43 a	8,48 a	54,69 a	9,72 a
Hydro-priming	73,92 b	73,42 b	72,00 b	24,09 b	9,46 c	10,96 b	75,32 b	12,14 b
Osmo-priming	79,00 b	78,25 b	71,67 b	21,29 b	7,64 b	10,72 b	76,19 b	10,82 ab
LSD.05	10,25	10,91	11,22	3,41	1,11	1,37	10,96	1,76

The mean followed by the same letter is not significantly different, P<0.05

Priming significantly improved viability and vigor of all cultivars especially on maximum growth potential, germination percentage, vigor index, growth speed, plumule length, radicle length, fresh weight, and dry weight (Table 1). Hydropriming was not significantly different to osmopriming, however, had the highest effect in improvement of vigor index (72,00%), growth speed (24,09%/etmal), plumule length (9,46 cm), radicle length (10,96 cm), and dry weight (12,14 mg).

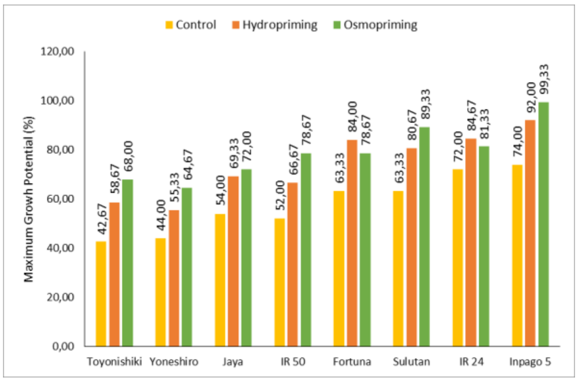

Figure 1. The effect of various seed priming methods on the maximum growth potential of several rice varieties

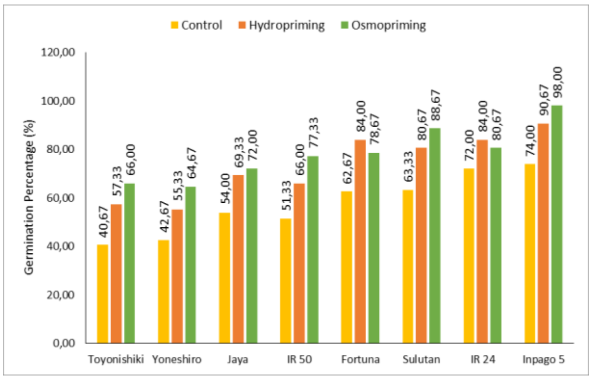

Figure 2. The Effect of various seed priming methods on the germination percentage of several rice varieties

Cultivar Inpago 5 treated to hydropriming had the highest values on vigor index (90,67%), radicle length (15,75 cm), fresh weight (123,24 mg), and dry weight (17,37 mg) (Figure 4, Figure 5, Figure 6, and Figure 7). Inpago 5 has better germination and growth ability in many variables.

Hydropriming and osmopriming with PEG 6000 expedite seed hydration, promoting rapid moistening and initiating germination before radicle emergence [23]. Priming facilitates early germination by stimulating enzymes crucial for the process [24] and enhancing metabolic speed [25]. Low-quality seeds, often resulting from Reactive Oxygen Species (ROS), instigate cell membrane phospholipid degradation, structural molecular damage, functional protein impairment, and genetic material damage [26]. Priming addresses this by repairing damaged cellular components, reducing electrolyte leakage, and restoring biomolecules such as DNA, RNA, proteins, enzymes, and membranes [27] [28]. Additionally, priming boosts the energy load [8], enabling plants to generate more metabolites [25].

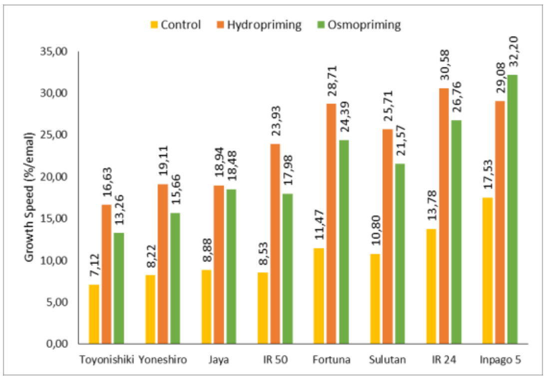

Figure 3. The effect of various seed priming methods on the speed growth of several rice varieties

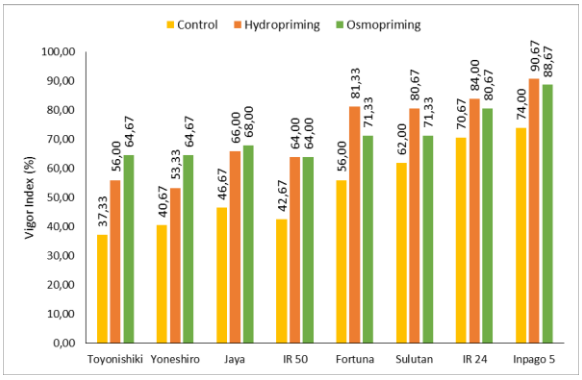

Figure 4. The effect of various seed priming methods on the vigor index of several rice varieties

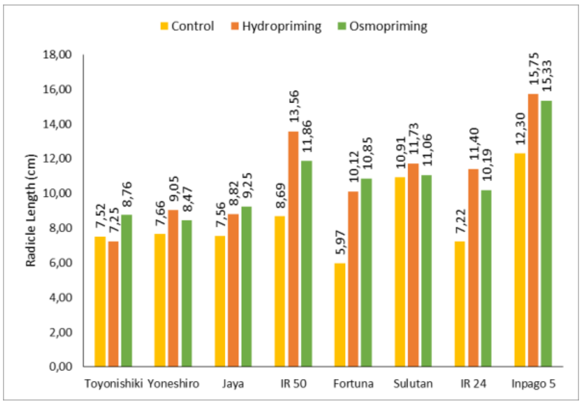

Figure 5. Effect of various seed priming methods on radicle length of several rice varieties

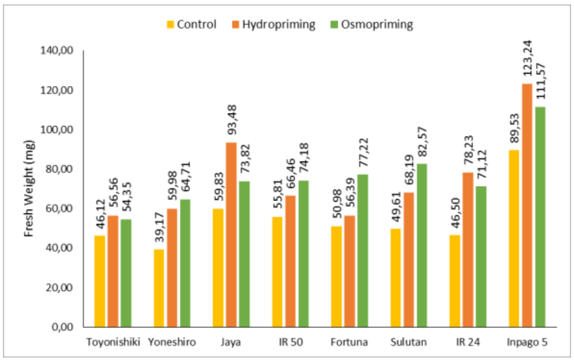

Figure 6. The effect of various seed priming methods on the fresh weight of several rice varieties

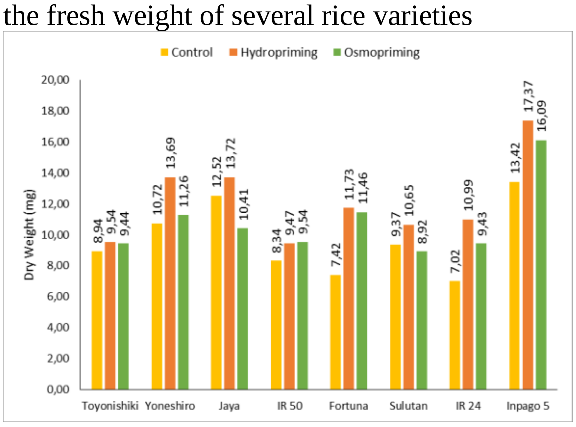

Figure 7. The effect of various seed priming methods on the dry weight of several rice varieties

Table 2. Effect of various seed priming methods on plumule length of several rice varieties

Varieties	Priming		
	Control	Hydropriming	Osmopriming
Toyonishiki	5,38 abcd	10,04 ijk	6,02 bcde
Yoneshiro	5,88 bcde	8,82 ghij	7,18 cdefg
Jaya	5,28 abc	10,52 jk	6,62 bcdef
IR 50	5,29 abc	8,42 fghi	7,21 defg
Fortuna	3,70 a	9,19 hij	7,25 defg
Sulutan	5,61 abcde	7,45 efgh	7,48 efgh
IR 24	5,02 ab	9,31 hij	6,50 bcde
Inpago 5	7,29 defg	11,92 kl	12,87 l
LSD.05		1,91	

The mean followed by the same letter is not significantly different $P<0.05$

Table 3. Improvement of seed viability and vigor of various rice varieties by priming treatment

Variables	Priming	Seed Germination Range							
		41-50		51-60		61-70		71-80	
		Toyonishiki	Yoneshiro	Jaya	IR 50	Fortuna	Sulutan	IR 24	Inpago 5
MGP (%)	Hydropriming	37,50	25,76	28,40	28,21	32,63	27,37	17,59	24,32
	Osmopriming	59,38	46,97	33,33	51,28	24,21	41,05	12,96	34,23
GP (%)	Hydropriming	40,98	29,69	28,40	28,57	34,04	27,37	16,67	22,52
	Osmopriming	62,30	51,56	33,33	50,65	25,53	40,00	12,04	32,43
VI (%)	Hydropriming	50,00	31,15	41,43	50,00	45,24	30,11	18,87	22,52
	Osmopriming	73,21	59,02	45,71	50,00	27,38	15,05	14,15	19,82
GS (%)	Hydropriming	133,59	132,44	113,25	180,62	150,27	137,94	122,01	65,84
	Osmopriming	86,30	90,46	108,01	110,84	112,61	99,64	94,27	83,64
PL (%)	Hydropriming	86,70	49,96	99,20	85,56	148,14	32,74	59,07	63,43
	Osmopriming	11,85	22,11	25,34	29,55	95,80	33,25	36,19	76,50
RL (%)	Hydropriming	-3,58	18,17	16,60	56,13	69,45	7,51	58,05	28,07
	Osmopriming	16,49	10,59	22,24	36,53	81,69	1,34	41,16	24,67
FW (%)	Hydropriming	22,63	53,15	56,24	19,08	10,62	37,46	68,25	37,65
	Osmopriming	17,84	65,21	23,39	32,92	51,48	66,44	52,96	24,62
DW (%)	Hydropriming	6,69	27,76	9,58	13,55	58,07	13,67	56,57	29,42
	Osmopriming	5,62	5,02	-16,86	14,50	54,48	-4,82	34,28	19,88

On the other hand, the most significant average increases in radicle length and increases in fresh weight occurred in the germination percentage range of 61-80%, and increases in dry weight occurred in the germination percentage range of 71 – 80% (Table 3). Seeds in this range demonstrate higher quality, enabling improved germination growth after priming. High-quality seeds possess superior physical, physiological, and pathological qualities, ensuring optimal growth and greater productivity [30].

4. Conclusion

Priming enhances maximum growth potential, germination percentage, vigor index, growth speed, plumule length, radicle length, fresh weight, and dry weight, as indicated by research results. Hydropriming outperformed osmopriming, resulting in higher vigor index, growth speed, plumule length, radicle length, and dry weight. Prim-ing is particularly effective in improving maximum growth potential, germination per-centage, vigor index, and growth speed within the lower germination percentage range of 41-60%. The most significant increases in radicle length, fresh weight, and dry weight through priming were observed in the higher germination percentage range of 61-80%.

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