Journal of Tropical Crop Science Vol. 12 No. 2, June 2025
www.j-tropical-crops.com

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

Effectiveness of Vermicompost Priming in Improving the Physiological Quality of Soybean Seeds

Dewi Rahmawati Intan Permatasari[A], Satriyas Ilyas[B*], Abdul Qadir[B]

[A] Seed Science and Technology Study Program, Graduate School, IPB University (Bogor Agricultural University), Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, Indonesia
[B] Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University (Bogor Agricultural University), Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, Indonesia

*Corresponding author; email: satriyas_ilyas@apps.ipb.ac.id

Abstract

Soybean seeds deteriorate rapidly, especially under humid tropics. An effective method for boosting seed germination is invigoration, which is applied as a pre-planting seed treatment to stimulate the metabolic activity in the seed. The research aimed to compare the effectiveness of vermicompost priming with other invigoration methods in improving the physiological quality of soybean seeds. The experiment was arranged in a split-plot, randomized design. The main plots were seed lots based on low, medium, and high germination of three soybean varieties (“Argomulyo”, “Detap 1”, and “Devon 1”). Subplot, invigoration method: control, matriconditioning with rice husk charcoal, a ratio of seed (g): rice husk charcoal (g): water (ml) 9:6:7 for 12 hours; osmoconditioning with 15% PEG 6000 solution, a ratio of seed (g): solution (mL) was 1:2 for 12 hours, and vermicompost priming with a ratio of seed (g): vermicompost (g): water (mL) 12:14:12 for 18 hours. Each experimental unit used 120 g of seeds. The invigoration treatment was conducted in a room with a temperature of 25 ± 2 °C and a relative humidity (RH) of 65-70%. The results showed that invigoration treatment can be used on soybean seeds with moderate viability (germination rate of 70-79%). In “Argomulyo” and “Detap 1”, the seed physiological quality increased with vermicompost priming, and in “Devon 1”, it increased with matriconditioning. The enhanced physiological quality of soybean seeds may be attributed to the complete nutrient and phytohormone content in vermicompost.

Keywords: invigoration, matriconditioning, seed deterioration, seed lot, viability, vigor

Introduction

Soybeans are widely used as an ingredient in the food and feed industries. Domestic demand for soybeans continues to increase. The volume of soybean imports in 2019 was 2.670.086 tons and is expected to increase until 2024 (Kementan, 2020). High-quality seeds, in terms of both morphology and physiology, are crucial for enhancing plant productivity. One of the limiting factors for soybean production in tropical regions is the rapid deterioration of soybean seeds during storage, which compromises the seed quality. Another problem is limited land suitable for soybean planting requirements. Planting under suboptimal conditions exposes plants to both biotic and abiotic environmental stress. Biotic stress is a stress condition caused by attacks from diseases, pests, or weeds. Abiotic stress is a stress condition resulting from drought, high or low temperatures, nutrient deficiencies, high salinity, or the presence of metal content. The presence of abiotic stress during planting can cause damage to plants and reduce production (Zhu, 2016).

Seed invigoration is a method for enhancing seed germination, performed as a pre-planting treatment to activate the seed’s metabolic system, making it ready to germinate but not until the radicle emerges (Ilyas, 2005). Invigoration can repair the physiology of seeds that have deteriorated. Matriconditioning, also known as matrix-priming, is a method of treating seeds by moistening them with moist solid media as the carrier. The solid carriers include compost, clay, peat, sand, and vermiculite. In some conditions, matriconditioning is more effective than osmoconditioning (Ilyas, 2012). Solid media stimulates planting in the field and increases oxygen availability (Pedrini et al., 2020). In Sucahyono et al. (2013) soybean seeds were treated with matriconditioning + biological fertilizer for 12 hours at room temperature. The water used for matriconditioning was dissolved in biological fertilizer containing Rhizobium N_2-fixing bacteria, P-solubilizing bacteria, fungicide-producing bacteria, and growth hormone-producing

Journal of Tropical Crop Science Vol. 12 No. 2, June 2025
www.j-tropical-crops.com
Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

endophytic bacteria. The germination increased to 91.43% compared to the control of 82.75%. Wahyuni et al. (2021) invigorated soybean seeds with rice husk charcoal matriconditioning + *Trichoderma asperellum* or *Pseudomonas aeruginosa* for 3 hours at room temperature had better vegetative growth, specifically plant height, leaf number, and leaf width. Nyoni et al. (2020) found that matriconditioning with sand for six hours on maize, cowpea, sorghum, and pearl millet seeds accelerated germination and enhanced the growth of plants in the field. Wahyuni et al. (2021), inorganic fertilizers can be reduced by providing matriconditioning treatment and applying organic fertilizer. Sari et al. (2022) reported that osmoconditioning soybean seeds using a 15% PEG 6000 solution for three hours resulted in the highest maximum growth potential (73.75%) compared to other osmoconditioning treatments. Priyanto (2017), the efficacy of matriconditioning invigoration treatment, comprising sawdust and vermiculite, in enhancing the viability of deteriorated soybean seeds has been demonstrated to exceed that of osmoconditioning invigoration treatment. The underlying mechanism of this phenomenon is attributed to the enhanced control of the imbibition process within the seeds during matriconditioning, attributable to the high water-holding capacity of the matriconditioning material. In contrast, osmoconditioning invigoration lacks this capacity, resulting in the direct entry of water into the membrane during the imbibition process. This phenomenon can lead to membrane damage.

Vermicompost is a form of organic matter generated via the combined activities of earthworms and microorganisms, which break down organic waste material. It contains plant growth regulators (gibberellin, cytokinin, and auxin), as well as macro- and micronutrients. Benazzouk et al. (2019), vermicompost leachate solution for seed priming can increase the germination of canola seeds by up to 50.67%. Vermicompost also contains humic acids and antioxidants. The use of vermicompost can also provide nutritional input to seeds. Muhie et al. (2020) found that vermicompost priming enhances the physiological quality of shallot seeds under simulated conditions of drought stress, salinity stress, and high temperature. Nevertheless, the opposite result was observed in research by Ievinsh (2011), where priming with vermicompost on carrot, cabbage, Swedish turnip, and tomato seeds inhibited seed germination, as indicated by a decrease in germination rates. Vithirak and Iwai (2019) found that vermicompost priming treatments at 75% and 100% concentrations inhibited the germination of lettuce seeds of the Roman and Batavia varieties. Vermicompost, especially animal manure, has been observed to have higher salt content (electrical conductivity) or excessive amounts of nutrients in greater concentrations. Huy and Iwai (2018), a high concentration of salinity reduced the seed's ability to absorb water and nutrients. The research aimed to compare the effectiveness of vermicompost priming with other invigoration methods in improving the physiological quality of soybean seeds.

Material and Methods

The soybean seeds used are “Argomulyo”, “Detap 1”, and “Devon 1” varieties. Soybean seeds were obtained from the Indonesian Legumes and Tuber Crops Research Institute. Susanto and Nugrahaeni (2016), “Argomulyo”, and “Devon 1” are superior varieties of soybean seeds, characterized by large seed sizes. The weight of 100 “Argomulyo” seeds is 16 g and “Devon 1” weighs 15 g. “Devon 1” contains high levels of isoflavones, is somewhat resistant to lodging, and is resistant to pod splitting (Bantolo, 2021), whereas “Detap 1” has the characteristics of being resistant to pod splitting. Initial germination of all soybean seed varieties ranged from 80-95%.

Vermicompost was made from cow dung obtained from the Faculty of Animal Science, IPB University. Testing for the nutrient and phytohormone content, as well as physical and chemical attributes, in vermicompost was conducted at the Soil Research Institute.

The experiment was arranged in a split-plot completely randomized design with four replications. The main plots were based on seed lots, categorized by their viability level: low (60-65% viability, Lot 1), medium (70-79% viability, Lot 2), and high (≥ 85% viability, Lot 3). Subplots were seed invigoration methods, matriconditioning with rice husk charcoal (I1), osmoconditioning with PEG 6000 (I2), and vermicompost priming (I3). In this experiment, three varieties were used as comparisons to determine the effect of treatment on each variety.

The experiment began by dividing the soybean seeds of “Argomulyo”, “Detap 1”, and “Devon 1” varieties into three different lots. Determination of seed lots was carried out using accelerated aging according to ISTA (2018), with modifications as described by Mustika et al. (2014). Accelerated aging was conducted as the natural seed lots with different ages for each variety were not available. A sieve with a pore size of 1.7 mm^2 was inserted into a plastic box, and then 420 mL of distilled water was poured into the box. Soybean seeds 250 g were placed in a sieve and put in a plastic box but did not reach the distilled water. The plastic box was placed in an incubator at a

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

temperature of 45-50 °C with a relative humidity (RH) of 87-90%. Soybean seeds were exposed to artificial aging for 2.5 hours for Lot 2 and 5 hours for Lot 1. The seeds that had been treated were air-dried for 1 hour at room temperature (25±2°C and RH 65-70%). Lot 3 were the seeds without aging.

The vermicompost priming treatment was performed using a layering technique (Figure 1). Vermicompost was ground until it passed a 0.5 mm sieve. The ratio of seed: vermicompost: water was 12:14:12 (w/w/v). The seeds were left at room temperature (25±2°C and RH 65-70%) for 18 hours. Matriconditioning with rice husk charcoal was carried out, according to Sucahyono et al. (2013). Rice husk charcoal was placed in the oven for 24 hours at 105°C and then ground until it passed through a 0.5 mm sieve (Ilyas and Sopian, 2013). The ratio of seeds, rice husk charcoal, and water was 9:6:7 (w/w/v). The seeds were left at room temperature (25±2 °C and RH 65-70%) for 12 hours. Osmoconditioning was carried out according to Yuanasari et al. (2015). Soybean seeds were soaked in 15% PEG 6000 solution for 12 hours. The ratio of seed and solution was 1:2 (w/v). Each experimental unit used 120 g of seeds. The seeds that had been treated were air-dried for 3 × 24 hours at room temperature (25 ± 2 °C and RH 65-70%). After treatment, the soybean seeds were tested for vigor index (VI), germination percentage (G), germination speed (GS), radicle emergence (RE), and electrical conductivity (EC).

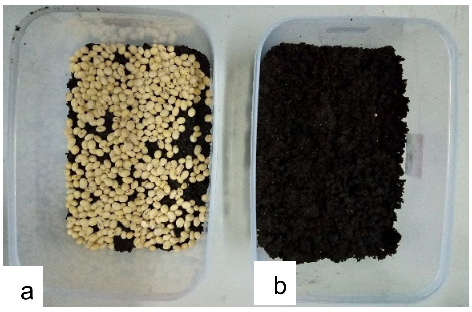

Figure 1. The vermicompost priming of soybean seeds employed a layering technique, where (a) the seeds are placed on a layer of the moist vermicompost, and (b) the entire mixture is covered with additional moist vermicompost.

The data analysis was conducted using ANOVA with a significance level set at 5%. Subsequently, the Duncan multiple range test was used to further examine the test results. The data was analyzed using Microsoft Excel 2016 and SAS on Demand for Academics.

Results and Discussion

Vermicompost Nutritional Content

Table 1 shows that the vermicompost contains complete macro- and micronutrients, as well as phytohormones such as auxin (IAA), gibberellins, cytokinins (zeatin and kinetin), and abscisic acid. The most dominant macronutrient element is nitrogen (N), which accounts for 1.57%. The most dominant micronutrients are aluminum 23 ppm and boron 20 ppm. The presence of nitrogen-fixing bacteria plays a crucial role in facilitating biological nitrogen fixation. Organic nitrogen is not directly available for plants and must be converted to ammonium or nitrate with the help of nitrogen-fixing bacteria. The nitrogen-fixing bacteria mechanism can be carried out through symbiotic and non-symbiotic mechanisms. The availability of nitrogen-fixing bacteria can help increase plant productivity by enhancing biological nitrogen fixation and increasing the availability and absorption of nutrients (Sapalina et al., 2022).

Phosphate, or phosphorus, is an essential nutrient element for plants, ranking second only to nitrogen. Vermicompost contains phosphate-solubilizing bacteria and fungi, also known as phosphate-solubilizing microbes. The existence of phosphate-solubilizing microbes is beneficial for plants because they can hydrolyze organic phosphate compounds and inorganic phosphate from insoluble compounds by reducing soil pH, chelation, and mineralization (Santosa and Pratiwi, 2022).

The presence of *Trichoderma* sp. in vermicompost enhances the beneficial microorganisms for plants. Trichoderma sp. is a soil saprophytic fungus that can attack several pathogenic fungi. *Trichoderma* can produce growth regulators such as indole acetic acid (IAA) and gibberellins (Syofian and Anhar, 2022). Those hormones can stimulate plant growth by increasing the rate of root growth, thereby enhancing their ability to absorb water and nutrients from the soil. Additionally, *Trichoderma* sp. can dissolve phosphate more effectively (Syofian and Anhar, 2022).

Effect of Seed Lot and Invigoration on Soybean Seed Quality

Regarding the technical guidelines for soybean seed quality certification issued by Kementan (2022), the minimum germination for the breeder seed class is 70%. The determination of the seed lot is based on the seed quality certification standard, and seeds with germination below and above the minimum standard are taken. A decline in seed germination is often due to seeds that have been stored for an excessive

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

period or to inadequate storage conditions. The duration of seed storability is influenced by the vigor of seed storage under suboptimal conditions and can be assessed using physical and chemical methods of rapid seed aging (Sadjad, 1994). Consequently, the present study employed an accelerated aging method to facilitate the deterioration of soybean seed quality.

In the "Argomulyo" variety, electrical conductivity (EC) was influenced by a single factor: seed lot treatment (Table 2). The value of EC Lot 3 was significantly higher than that of Lot 1 and Lot 2, with a difference of 9-12 $\mu S.cm^{-1}.g^{-1}$. Electrical conductivity measures the integrity of the seed membrane. Seeds with high vigor will be stronger in maintaining membrane integrity, resulting in more minor membrane leakage and EC. The "Argomulyo" seeds produced EC, which contradicts the existing theory. Lot 3, which had the highest viability, had the highest EC. According to Saenong (1986), the limitation of EC testing is that the resulting value is the average of the seed population. In the "Detap 1" variety, the seed lot had a significant effect on GS (Table 2). Seed with high initial viability (Lot 3, 83.5%), had the highest GS of 22.25 %/etmal but was not significantly different from Lot 1. Seed

Table 1. Vermicompost components

No.	Vermicompost components	Value	Unit	Analysis method
1	C – organic	39.02	%	Gravimetry
2	C/N	25.00	-	-
3	Macronutrients			
	N	1.57	%	H_2O/F-AAS
	P_2O_5	0.42	%	H_2O/F-AAS
	K_2O	0.26	%	H_2O/F-AAS
	Na	0.12	%	H_2O/F-AAS
	CaO	0.05	%	H_2O/F-AAS
	MgO	0.09	%	H_2O/F-AAS
4	Micronutrients			
	Fe	11.00	ppm	H_2O/F-AAS
	Mn	1.90	ppm	H_2O/F-AAS
	Cu	1.40	ppm	H_2O/F-AAS
	Zn	2.60	ppm	H_2O/F-AAS
	Al	23.00	ppm	H_2O/F-AAS
	B	20.00	ppm	H_2O/F-AAS
8	Cation exchange capacity	59.03	c mol $_c$/kg	NH_4OAC pH 7-Spectrophotometry
9	Humic compounds	6.69	%	Spectrophotometry
10	Nitrogen-fixing bacteria	2.87×10^9	$CFU.g^{-1}$	Total plate count
11	Phosphate solubilizing bacteria	1.30×10^9	$CFU.g^{-1}$	Total plate count
12	Phosphate solubilizing fungi	4.52×10^4	$CFU.g^{-1}$	Total plate count
13	*Trichoderma* sp.	2.87×10^9	$CFU.g^{-1}$	Total plate count
14	N-fixing Activity	Positive	-	Drop plate
15	P-solubilizing activity	Positive	-	Drop plate
16	Phytohormones			
	IAA	10.044	$mg.kg^{-1}$	HPLC
	Gibberellins	17.076	$mg.kg^{-1}$	HPLC
	Zeatin	6.917	$mg.kg^{-1}$	HPLC
	Kinetin	5.070	$mg.kg^{-1}$	HPLC
	Abscisic acid	6.677	$mg.kg^{-1}$	HPLC

Notes: CFU is colony forming unit; F-AAS is flame atomic absorption spectrometer; HPLC is high-performance liquid chromatography.

Journal of Tropical Crop Science Vol. 12 No. 2, June 2025
www.j-tropical-crops.com
Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

with medium initial viability (Lot 2) had the lowest GS of 20.25% etmal. In “Devon 1”, VI was significantly influenced by seed lot. Lot 3 had the highest VI (84.5%).

Invigoration treatment influenced all the variables except EC in “Argomulyo” and VI on “Devon 1” (Table 3). In “Argomulyo”, I2 (osmoconditioning with PEG 6000) reduced VI, GP, and GS. The vigor index increased by 7.33% when treated with vermicompost priming, but the difference was not statistically significant compared to the control. Treatments I1 (matriconditioning with rice husk charcoal) and I3 (vermicompost priming) significantly increased germination by 5-10% and radicle emergence by 20-30% compared to the control. The germination in treatment I3 was the highest (92.67%) compared to other invigoration treatments. The highest vigor index (84%) was also obtained in treatment I3 but was not significantly different from the control.

In “Detap 1”, the invigoration treatment had a significant effect on all variables (Table 3). Invigoration treatments I1 and I3 significantly increased the vigor index by 15-20% and germination by 10-15% compared to the control. The invigoration I1, I2, and I3 reduced EC compared to the control. The lowest EC was found in treatment I2 (37.12 $\mu S.cm^{-1}.g^{-1}$). This shows that invigoration does not damage the integrity of the seed cell membrane. The I2 treatment reduced the GS by 2.56% from I0, while the I1 and I3 treatments were not significantly different from the control. Radicle emergence in treatment I1 (60.67%) significantly increased compared to the control.

All variables except VI were significantly influenced by invigoration treatment in “Devon 1” (Table 3). Invigoration treatments significantly increased the germination percentage by 8-11% compared to the control, and the germination percentage values did not differ significantly between the invigoration treatments. The germination in treatment I3 was the highest (89.33%) compared to other invigoration treatments. Treatment I3 produced the lowest GS compared to other invigoration treatments and the control. The I1 and I2 invigoration treatments significantly increased RE by 15-30% compared to the control. Radicle emergence in the vermicompost priming treatment increased, but the increase was not statistically significant compared to the control. Invigoration treatments resulted in lower EC compared to the control. The lowest EC was found in treatment I2 (39.92 $\mu S.cm^{-1}.g^{-1}$).

A decrease in GS and RE values was not significantly different from the control in the vermicompost priming treatment of the “Devon 1” variety (Table 3). This can be attributed to the longer duration of 18 hours for matriconditioning and osmoconditioning, compared to 12 hours. The study by Mariani and Wahditiya (2021) shows that matriconditioning treatment of soybean seeds for 6 and 12 hours is more effective than for 18 hours. It is noteworthy that the moist condition of the matriconditioning media has the potential for the presence of pathogenic bacteria. Germination is divided into three phases based on the level of seed water content and duration: imbibition (first phase), activation (second phase), and growth (third phase), which is marked by the emergence of the radicle. The unprimed seed will immediately enter the third phase. In seed priming, the duration of the second phase is extended, and then the water content of the seeds is reduced until it is safe for the seeds to be stored (Pedrini et al., 2020). A longer priming

Table 2. Effect of seed lot on the physiological quality of soybean seeds of “Argomulyo”, “Detap 1”, and “Devon 1” varieties

Varieties	Seed lot	Seed physiological quality				
		VI (%)	G (%)	GS (% / etmal)	RE (%)	EC ($\mu S.cm^{-1}.g^{-1}$)
“Argomulyo”	Lot 1	76.25a	82.50a	22.02a	55.25a	56.77b
	Lot 2	77.75a	88.00a	22.43a	64.00a	54.43b
	Lot 3	79.75a	86.25a	22.29a	63.75a	66.40a
“Detap 1”	Lot 1	65.75a	79.75a	21.57a	53.75a	43.93a
	Lot 2	64.00a	76.50a	20.25b	47.00a	44.98a
	Lot 3	70.25a	83.50a	22.25a	53.50a	42.32a
“Devon 1”	Lot 1	74.50b	82.75a	19.51a	68.00a	48.35a
	Lot 2	77.50b	85.75a	19.96a	70.25a	46.83a
	Lot 3	84.50a	89.25a	19.84a	71.25a	47.99a

Notes: Seed lot with low germination of 60-69% (Lot 1), medium 70-79% (Lot 2), high >80% (Lot 3). Values followed by the same letter for each variable indicate that the results are not significantly different in the DMRT test at α = 0.05.

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

duration causes the seeds to enter the third phase of imbibition, allowing the radicle to emerge, albeit minimally. In this phase, the seeds are sensitive to desiccation. According to Ruliyansyah (2011), priming legume seeds for an extended period potentially reduces oxygen availability during seed respiration. A faster priming duration can be chosen to minimize seed damage and maintain optimum seed quality.

The osmoconditioning treatment caused the seeds to imbibe more quickly than the matriconditioning and vermicompost priming treatments. Matriconditioning and vermicompost priming enable seeds to undergo a more extended imbibition phase compared to osmoconditioning. Matriconditioning and vermicompost priming media have good water-holding capacity. Meanwhile, osmoconditioning media is a solution that lacks water-holding capacity. Water directly enters the cell membrane, allowing the imbibition process to occur quickly (Priyanto, 2017). Osmoconditioning is unsuitable for soybean seeds because they are sensitive to imbibitional injury. The water absorption rate in osmoconditioning is faster and less controlled than in matrix conditioning and vermicompost priming. Therefore, G and GS in the "Argomulyo" and "Detap 1" varieties decreased after osmoconditioning treatment (Table 3).

Table 4 shows that all invigoration treatments significantly increased the germination in Lot 1 of "Devon 1" from 70% (control) to 84-91%. In Lot 2, only matriconditioning increased germination from 80% to 93%. In Lot 3, with an initial germination rate of 87%, none of the invigoration treatments significantly improved germination.

In "Devon 1", osmoconditioning showed the lowest EC compared to other invigoration treatments in Lot 1 and Lot 3. In Lot 2, the lowest EC value was found in vermicompost-primed samples, although it was not significantly different from the osmoconditioned samples. The EC from the matriconditioned seed was not significantly different from the vermicompost primed seed in Lot 1 and Lot 3 but was lower than the control. The EC values among seed lots were not significantly different in all invigoration treatments, except for I3, where the EC of Lot 2 was lower than Lot 1 and Lot 3.

Matriconditioning and vermicompost priming are more effective in improving the physiological quality of soybean seeds (Tables 3 and 4). Numba et

Table 3. Effect of invigoration method on the physiological quality of soybean seeds of "Argomulyo", "Detap 1", and "Devon 1" varieties

Varieties	Invigoration Methods	Seed physiological quality				
		Vigor index (%)	Germination (%)	Germination speed (% / etmal)	Radicle emergence (%)	Electrical conductivity ($\mu S.cm^{-1}.g^{-1}$)
"Argomulyo"	Control (I0)	76.67ab	83.33b	23.22a	49.00b	63.02a
	Matriconditioning with rice husk charcoal (I1)	78.67ab	89.00a	23.01a	75.33a	61.73a
	Osmoconditioning with 15% PEG (I2)	72.33b	77.33c	19.60b	48.67b	55.99a
	Vermicompost priming (I3)	84.00a	92.67a	22.99a	71.00a	56.05a
"Detap 1"	Control	57.00b	74.67b	21.61a	43.33b	50.64a
	Matriconditioning with rice husk charcoal (I1)	75.67a	87.00a	22.63a	60.67a	43.96b
	Osmoconditioning with 15% PEG (I2)	54.33b	69.67b	19.05b	50.33ab	37.12c
	Vermicompost priming (I3)	79.67a	88.33a	22.14a	50.33ab	43.24b
"Devon 1"	Control	76.00a	79.00b	19.82a	58.00c	57.73a
	Matriconditioning with rice husk charcoal (I1)	78.67a	87.67a	20.53a	83.33a	46.45b
	Osmoconditioning with 15% PEG (I2)	76.00a	87.67a	19.95a	73.00ab	39.92c
	Vermicompost priming (I3)	84.67a	89.33a	18.78b	65.00bc	46.79b

Notes: Values followed by the same letter for each variable indicate that the results are not significantly different in the DMRT test at α = 0.05.

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

al. (2024) stated that rice husk charcoal contains elements N, K, and C because it has gone through a combustion process, thus the carbon content is high and easily decomposed. Matriconditioning seeds with husk charcoal can prolong the imbibition phase. This prolonged imbibition process allows for the controlled entry of water, thereby increasing the germination percentage of soybean seeds that have experienced a decline in seed quality. Matriconditioned black soybean (*Glycine soja*) seeds with rice husk charcoal plus biofertilizer (consisting of nitrogen-fixing bacteria, phosphate-solubilizing bacteria, fungicide-producing bacteria, and growth-regulator-producing endophytic bacteria) significantly increased the percentage and rate of germination and vegetative growth (Sucahyono et al., 2013). Matriconditioning plus *Bradyrhizobium japonicum* dan *Azospirillum lipoferum* applied on soybean (*Glycine max*) seeds improved the seed quality, plant growth (number of nodules, weight of roots), and reduced use of N fertilizer (Ilyas et al., 2003).

Incorporation of vermicompost in seed priming can significantly enhance the quality of seeds by their rich nutrient content. Vermicompost has a water-holding capacity that positively affects the swelling of the seed coat (Abzhami et al., 2024). In addition, vermicompost contains growth regulators such as IAA, gibberellin, kinetin, zeatin, and abscisic acid (Table 1). Humic compounds and growth-regulating substances in the vermicompost composition start the cell cycle and a series of sequential divisions of meristem cells (Abzhami et al., 2024). It is recognized that humic compounds activate enzymes involved in the cell cycle and DNA replication (cyclin-dependent kinases) (Wolny et al., 2018), induce root growth, enhance the functional activity of H-ATPase, stimulate plant growth by improving the availability of iron and zinc ions, polyamines (Pizzeghello et al., 2020 and Younas et al., 2021). Cytokinins and gibberellic acid regulate the formation and development of soybean shoots.

Osmoconditioning reduced the seed EC values (Tables 3 and 4). According to Sa'adati et al. (2023), the particles contained in polyethylene glycol (PEG) can protect seeds because these particles form a thin layer on the outer cell membrane, controlling the entry of water and oxygen into the seeds. This condition is supported by the statement of Fata et al. (2020) that PEG solution will reduce the environmental water potential through increased osmotic potential; therefore, it will slow down the rate of water absorption in the seed and reduce cell electrolyte loss. These conditions result in the osmoconditioned seeds having higher germination and radicle emergence than the control in "Devon 1"; however, the osmoconditioning treatment reduced G and GS in "Argomulyo" and "Detap 1". PEG solution limits the amount of water absorbed by the seeds, allowing the rate of water absorption at the beginning of imbibition (phase I) to be slowed down and extend the duration of phase II. A long duration in phase II is needed to repair their metabolism before entering phase III for radicle formation. Low leakage indicates that the seeds can maintain a supply of energy sources for breaking down lipids and carbohydrates needed for germination (Aisyah et al., 2018).

Table 4. Effect of the Interaction between seed lot and invigoration method on germination and electrical conductivity of "Devon 1" soybean seeds

Varieties	Seed Lot	Invigoration methods			
		Control (I0)	Matriconditioning with rice husk charcoal (I1)	Osmoconditioning with 15% PEG (I2)	Vermicompost priming (I3)
Germination (%)					
"Devon 1"	Lot 1	70 Bb	86 Aa	84 Ba	91 Aa
	Lot 2	80 Ab	93 Aa	85 ABab	85 Aab
	Lot 3	87 Aa	84 Aa	94 Aa	92 Aa
Electrical Conductivity ($\mu S.cm^{-1}.g^{-1}$)					
"Devon 1"	Lot 1	60.93 Aa	45.66 Ab	37.04 Ac	49.76 Ab
	Lot 2	55.88 Aa	47.76 Ab	41.69 Ac	41.20 Bc
	Lot 3	56.38 Aa	45.93 Abc	41.03 Ac	48.63 Ab

Notes: Seed lot with low germination of 60-69% (Lot 1), medium 70-79% (Lot 2), high >80% (Lot 3). Values followed by the same letter indicate that the results are not significantly different in the DMRT test at the α = 0.05. Uppercase letters compare among rows in the same column. Lowercase letters compare among columns on the same row.

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

Conclusions

Vermicompost priming enhanced the physiological quality of “Argomulyo” and “Detap 1” soybeans, as indicated by improved vigor index, higher germination percentage, faster germination speed, and earlier radicle emergence. The seed physiological quality of “Devon 1” increased with matriconditioning using rice husk charcoal. Vermicompost priming improved the physiological quality of soybean seeds but was not significantly different from matriconditioning. Invigoration significantly improved the seed quality of “Devon 1” soybeans, with a medium germination rate of 70%, but was less effective on seeds that still exhibited high germination rates (≥87%).

References

Abzhami, Z., Turasheva, S., Tleubayeva, D., Boguspaev, K.K. (2024). Effect of short-term seed priming on germination of wild-growing plant *Scorzonera tau-saghyz*. *BIO Web of Conferences* **100**, 1-7. DOI: https://doi.org/10.1051/bioconf/202410002003.

Aisyah, D.N., Kendarini, N., Ashari, S. (2018). Effectiveness of PEG-6000 as osmoconditioning treatment in improving soybean (*Glycine max* L. Merr.) seed performance and yield. *Jurnal Produksi Tanaman* **6**, 1344-1353.

Bantolo. (2021). “The Ministry of Agriculture has developed two soybean varieties, “Devon 1” and “Detap 1”, with a potential yield of 3.09 tons per hectare”. agrofarm.co.id/2021/02/33461/ [June 7, 2023].

Benazzouk, S., Djazouli, Z.E., and Lutts, S. (2019). Vermicompost leachate as a promising agent for priming and rejuvenation of salt-treated germinating seeds in *Brassica napus*. *Communications in Soil Science and Plant Analysis* **50**, 1344–1357. DOI: https://doi.org/10.1080/00103624.2019.1614608.

Fata, N.A.N., Supriyanto, E.R., and Sudrajat, D. J. (2020). Invigoration treatment of white jabon (*Neolamarckia cadamba* (Roxb.) Bosser) seeds using polyethylene glycol and ultrafine bubbles. *Jurnal Perbenihan Tanaman Hutan* **8**, 11– 24. DOI: https://doi.org/10.20886/bptpth.2020.8.1.11-24.

Huy, V., and C. B. Iwai. (2018). Utilization of wastewater on seed germination and physiological parameters of rice (*Oryza sativa* L.) *In* IOP Conference Series: Materials Science and Engineering. September 20-12, 2017, Banda Aceh, Indonesia.

Ievinsh, G. (2011). Vermicompost treatment differentially affects seed germination, seedling growth, and the physiological status of vegetable crop species. *Plant Growth Regulation* **65**, 169–181. DOI: https://doi.org/10.1007/s10725-011-9586-x.

Ilyas, S. (2005). Seed invigoration *In* “Seed Vigor Internship for Staff of the Food Crops and Horticulture Seed Quality Development Center at the Seed Science and Technology Section”. Department of Agronomy and Horticulture, Faculty of Agriculture, IPB. Bogor, 6-19 December 2005.

Ilyas S. (2012). “Seed Science and Technology: Theory and Research Results”. Bogor. IPB Press.

Ilyas, S., and Sopian, O. (2013). Effect of seed maturity and invigoration on seed viability and vigor, plant growth, and yield of bambara groundnut (*Vigna subterranea* (L.) Verdc). *Acta Horticulture* **979**, 695-702. DOI: https://doi.org/10.17660/ActaHortic.2013.979.78.

Ilyas, S., Surahman, M., Saraswati, R., Gunarto, L., and Adisarwanto, T. (2003). “Improvement of Seed Quality and Productivity of Soybean by Seed Invigoration Technique Using Matriconditioning and Microbial Inoculants.” Research Report of the Center for Participatory Agricultural Technology Assessment Project (PAATP), Ministry of Agriculture, Indonesia.

International Seed Testing Association. (2018). “International Rules for Seed Testing 2018”. ISTA, Basserdorf, CHE.

Kementerian Pertanian. (2020). “Center for Agricultural Data and Information Systems Secretariat General 2020: Agricultural Commodity Outlook Soybean Food Crops”. Kementan, Jakarta, Indonesia.

Kementerian Pertanian. (2022). “Decree of the Minister of Agriculture of the Republic of Indonesia on Technical Guidelines for Food Plant Seed Certification.” Kementan, Jakarta, Indonesia.

Mariani, and Wahditiya, A.A. (2021). Effect of matriconditioning treatment on viability and

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

vigor of soybean seeds (*Glycine max* L. Merrill). *Jurnal Agrotan* **7**, 55–67.

Muhie, S.H., Yildirim, E., Memis, N., and Demir, I. (2020). Vermicompost priming stimulated germination and seedling emergence of onion seeds against abiotic stresses. *Seed Science Technology* **48**, 153–157. DOI: https://doi.org/10.15258/sst.2020.48.2.02.

Mustika, S., Suhartanto, M. R., and Qadir, A. (2014). Soybean seed deterioration due to accelerated aging using IPB 77-1 MM and natural storage. *Bulletin Agronomi* **2**, 1-10. DOI: https://doi.org/10.29244/agrob.2.1.1-10.

Numba, S., Syam, N., Ashar J. R., and Fatmawati. (2024). Viability and vigor of soybean seeds (*Glycine max* L.) on the matriconditioning media from organic and inorganic materials. *Jurnal Galung Tropika* **13**, 45-58. DOI: https://doi.org/10.31850/jgt.v13i1.1225.

Nyoni, N., Ndlovu, E., and Maphosa. (2020). Effect of priming regimes on seed germination of field crops. *African Crop Science Journal* **28**, 169-176. DOI: https://doi.org/10.4314/acsj.v28i2.3.

Pedrini, S., Balestrazzi, A., Madsen, M.D., Bhalsing, K., Hardegree, S.P., Dixon, K.W., and Kildisheva, O.A. (2020). Review article: Seed enhancement: getting seeds restoration-ready. *Restoration Ecology* **28**, 266-275. DOI: https://doi.org/10.1111/rec.13184.

Pizzeghello, D., Schiavon, M., Francioso, O., Vecchia, F. D., Ertani, A., and Nardi, S. (2020). Bioactivity of size-fractionated and unfractionated humic substances from two forest soils and comparative effects on N and S metabolism, nutrition, and root anatomy of *Allium sativum* L. *Frontiers in Plant Science* **11**, 1-17. DOI: https://doi.org/10.3389/fpls.2020.01203.

Priyanto, Y.A. (2017). Viability of soybean seeds (*Glycine max* L. Merril) by matriconditioning and osmoconditioning invigoration. *Jurnal Hexagro* **1**, 1-10. DOI: https://doi.org/10.36423/hexagro.v1i1.120.

Ruliyansyah, A. (2011). Improved performance of legume seeds by invigoration treatment. *Jurnal Teknologi Perkebunan dan Pengelolaan Sumber Daya Lahan* **1**, 13-18. DOI: https://doi.org/10.26418/plt.v1i1.26.

Sadjad, S. (1994). "Quantification of Seed Metabolism". Jakarta. PT Widiasarana Indonesia.

Saenong, S. (1986). " Contribution of Initial Vigor to the Storability of Maize (*Zea mays* L.) and Soybean Seeds (*Glycine max* L. Merril)" [Dissertation]. IPB University, Bogor, Indonesia.

Sapalina, F., Ginting, E.N., and Hidayat, F. (2022). Nitrogen-fixing bacteria as biofertilizer agents. *WARTA Pusat Penelitian Kelapa Sawit* **27**, 41-50. DOI: https://doi.org/10.22302/iopri.war.warta.v27i1.80.

Sari, N.N.K., Suroso, B., Wijaya, I. (2022). Osmoconditioning invigoration on viability and vigor of soybean seeds of Biosoy 1 have been stored for more than six months. *UMJ Proceeding Series* **1**, 292-301. DOI: https://doi.org/10.32528/nms.v1i2.75.

Santosa, E., and Pratiwi, E. (2022). "Phosphate-Solubilizing Microbes. In Soil Biology Analysis Method". Center for Research and Development of Agricultural Land Resources, Bogor, ID.

Sa'adati, R., Kristanto, B.A., and Anwar, S. (2023). Viability response soybean seed (*Glycine max* L. Merill) due to concentration and soaking time invigoration polyethylene glycol. *Journal of Agricultural Science* **8**, 40-51. DOI: http://dx.doi.org/10.21776/ub.jpt.2023.008.1.5.

Sucahyono, D., Sari, M., Surahman, M., and Ilyas, S. (2013). Effect of invigoration applied on black soybean (*Glycine soja*) seed on seed vigor, plant growth, and yield. *Jurnal Agronomi Indonesia* **41**, 126-132. DOI: https://doi.org/10.24831/jai.v41i2.7517.

Susanto, G.W.A., and Nugrahaeni, N. (2016). " Introduction and Characteristics of Superior Soybean Varieties." Indonesian Legumes and Tuber Crops Research Institute, Malang, ID.

Syofian, W. M., and Anhar A. (2022). The effect of *Trichoderma* spp. against germination speed of batok glutinous rice seeds (*Oryza sativa* L. var. glutinosa). *Bioscience* **6**, 33-39. DOI: https://doi.org/10.24036/0202261109181-0-00.

Vithirak, H., and Iwai, C.B. (2019). Effect of vermicompost tea on seed germination of Green Romaine (*Lactuca sativa* L. var. Jericho) and Green Batavia (*Lactuca sativa*

Received 21/11/2024; Revised 26/03/2025; Accepted 14/04/2025
https://doi.org/10.29244/jtcs.12.02.274-283

L.var Concept) lettuce. *Khon Kaen Agriculture Journal* **47**, 399-408. DOI: https://doi.org/10.14456/kaj.2019.27.

Wahyuni, A., Putri, R., Hakim, N. A., Septiana. (2021). Enhancement of soybean growth using biological agents seed treatment and fertilization. *IOP Conference Series: Earth and Environmental Science* **1012**, 1-8. DOI: https://doi.org/10.1088/1755-1315/1012/1/012064.

Wolny, E., Betekhtin, A., Rojek, M., Braszewska-Zalewska, A., Lusinska, J., Hasterok. (2018). Germination and the early stages of seedling development in *Brachypodium distachyon*. *International Journal of Molecular Sciences* **19**, 1-7. DOI: https://doi.org/10.3390/ijms19102916.

Younas, M., Zou, H., Laraib, T., Abbas, W., Akhtar, M. W., Aslam, M. N., Amrao, L., Hayat, S., Hamid, T. A., Hameed, A., Kachelo, G. A., Elseehy, M. M., El-Shehawi, A. M., Zuan, A. T. K., Li, Y., Arif, M. (2021). The influence of vermicomposting on photosynthetic activity and productivity of maize (*Zea mays* L.) crop under semi-arid climate. *Plos One* **19**, 1-9. DOI: https://doi.org/10.1371/journal.pone.0256450.

Yuanasari, B.S., Kendarini, N., and Saptadi, D. (2015). Enhancement viability of black soybean (*Glycine max* L. Merr.) through invigoration osmoconditioning. *Jurnal Produksi Tanaman*. **3**, 518-527. DOI: https://doi.org/10.21176/protan.v3i6.230.

Zhu, J.K. (2016). Abiotic stress signaling and responses in plants. *Cell* **167**, 313-324. DOI: https://doi.org/10.1016/j.cell.2016.08.029.