THE EFFECT OF RICE HUSKS AND STORAGE DURATION ON GERMINATION RATE, SEED VIGOR, AND YIELD OF SOYBEANS (*Glycine max* L. Merr.) cv ANJASMORO

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ABSTRACT

Good seed storage conditions are part of the seed production chain, and storage methods that affect seed storage life and quality. The use of rice husks can indirectly increase seed viability and vigor in storage by balancing the moisture content of the seeds in the packaging with the surrounding humidity. This study aims to determine the optimal amount of rice husks for soybean seed storage over various storage periods. The study was conducted from February to July 2025 in Rancaekek Kencana Village, Bandung Regency, at an altitude of approximately 700 meters above sea level. The study used a completely randomized design (CRD) with a factorial pattern and four replicates. The first factor was the percentage of rice husks, with three levels: 0% (no rice husks), 25%, and 50%. The second factor was storage period, with four levels: 4, 8, 12, and 16 weeks. Observations consisted of seed moisture content, sprout weight, sprouting time, sprouting uniformity, and seed weight per planting, seed weight per plot, and yield per hectare. The results showed that there was an interaction between the percentage of rice husks and storage duration on moisture content and sprout weight after storage. The viability and vigor of soybean seeds stored for 16 weeks did not show any effect on various percentages of rice husks. This means that using rice husks as a mixture or storage medium for soybean seeds at various percentages did not affect seed viability or vigor after 16 weeks of storage. Regardless of the amount of rice husk used, soybean seed viability and vigor remained unchanged, indicating that rice husk was not a determining factor in reducing or maintaining seed quality during this storage period.

Keywords: Soybean; Storage; Viability; Vigor; Yield

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INTRODUCTION

Soybeans are an important food commodity widely used as a raw material for industry and household consumption. However, soybeans have several fundamental weaknesses that affect their shelf life and quality. One of the most important aspects is their chemical composition, which is dominated by high protein content, making them more reactive to environmental changes, particularly temperature and humidity. As a result, soybeans tend to deteriorate more quickly if not stored properly (Izzati, 2024).

The process of deterioration of soybean seeds during storage occurs more quickly compared to other plant seeds with rapid loss of seed vigor which causes a decrease in seed germination, so that soybean seeds to be planted must be stored in a favorable environment (low temperature), so that seed quality remains high until the end of storage (Egli et al. 2005; Viera et al. 2001).

Obtaining good seeds requires a series of seed technology activities, including seed production, processing, testing, certification, and storage. Seed damage can occur during seed processing, including harvesting, threshing, and drying (Reed et al. 2022).

The predominance of protein in soybean seeds makes the seed structure susceptible to denaturation and degradation under less-than-ideal storage conditions. Protein is hygroscopic, meaning it readily binds water molecules from the surrounding environment. This makes soybean seeds less durable because fluctuations in air humidity directly affect the stability of the seed's internal components. The higher the protein content, the greater the tendency of the seeds to absorb water and undergo physical and chemical changes (Sultana et al., 2024).

During storage, one of the main factors determining the level of soybean seed deterioration is the increase in seed moisture content. This increase in moisture content typically occurs due to the absorption of water vapor from the air, especially in storage areas without adequate humidity control. As seed moisture content increases, biological activities such as respiration and microbial growth intensify. This condition accelerates seed deterioration, resulting in decreased quality, discoloration, odor, and reduced germination (Tahir et al., 2023).

External factors are the main cause of post-harvest seed deterioration, both qualitatively and quantitatively. These factors can be physical, such as temperature and humidity, chemical, such as oxygen availability, or biological, such as bacteria, fungi, insects, and rodents (Ramanadane et al., 2024). This quality decline is a gradual, cumulative process that is irreversible due to physiological and biochemical changes. Physiological seed deterioration is characterized by reduced seed germination (Perdana et al., 2023).

Storage damage is also related to the interaction of the seeds with their environment. Moist soybean seeds provide an ideal environment for mold growth, especially those that attack foods with medium moisture content. Furthermore, increased internal moisture in the seeds triggers lipid oxidation, leading to rancidity. High soybean fat content accelerates deterioration, making long-term storage without special protection difficult (Cardoso et al., 2024).

Various methods and materials are used to slow deterioration during storage, including rice husk. Rice husk is often used as a moisture absorber or filler in traditional storage systems. The husk's hollow structure and insulating properties help reduce direct contact of the seeds with humid air. Therefore, the use of rice husk can help prevent an increase in moisture content in soybean seeds during storage (Corbineau, 2024).

The most important function of rice husks is to absorb the water content in the seeds in an airtight container, thereby maintaining a safe moisture content for storage. The amount of rice husks used determines the water absorption and humidity levels of the stored seed container (Duan et al., 2024). According to research by Jayanti et al. (2022), the storage medium's ability to maintain seed moisture content is crucial.

The use of rice husks in soybean storage can also extend the storage process. This is due to the husk's ability to stabilize the microenvironment around the seeds, including humidity and temperature. The husk acts as a natural buffer, slowing water absorption by the seeds and thereby extending the shelf life before the soybeans experience significant damage. Thus, rice husks can be a simple yet effective solution for maintaining soybean seed quality during storage (Sakya et al., 2023). Thus, storing soybean seeds with rice husks at the appropriate percentage can maintain seed quality longer than without them (Cahyono et al., 2025).

MATERIALS AND METHODS

The experiment was conducted at a plastic greenhouse in Rancaekek, Bandung Regency, from February to July 2025, at an altitude of approximately 700 meters above sea level and with a D4 rainfall type according to Oldeman (1975).

The materials used were Anjasmoro soybean seeds obtained from Balitkabi Malang, East Java; rice husks from the September 2024 rice harvest; 1.0 mm plastic bags; soil/sand for seed testing; distilled water; and labels. The tools used were an analytical scale, writing instruments, a cutter, a sprayer, a plastic tub, a germination tray, a portable seed moisture tester, and a ruler.

The experiment used a factorial pattern with a completely randomized design (CRD) for seed testing and a randomized block design (RBD) for field treatment, where the first factor was the percentage of rice husks (S), consisting of three levels, namely 0% rice husks (s0), 25% rice husks (s1), 50% rice husk (s2). The second factor was storage duration (W), with four levels: 4 weeks (w1), 8 weeks (w2), 12 weeks (w3), and 16 weeks (w4), yielding 12 treatment combinations, each repeated four times.

The field experiment was conducted on plots measuring 3 x 4 m2, with a planting distance of 25 x 25 cm2, a planting density of 192 planting holes, and 2 seeds per hole, resulting in 384 plants. Land preparation was carried out in two stages: plowing and harrowing. Fertilization was carried out with basic fertilizers (50 kg/ha of urea, 200 kg/ha of SP36, and 150 kg/ha of KCl), and Rhizoplus seeds were inoculated at 5 g/100 g. Maintenance consisted of weeding, pest and disease control, urea follow-up fertilization, and harvesting at 91 days after planting.

Observations were made on the growing environment and pest organisms as supporting observations, and the main observations consisted of water content measured by gravimetry, seed weight measured by analytical balance, germination power by plastic rolled paper test, germination time, and germination simultaneity by paying attention to normal germination criteria, and results were calculated per plant and converted per hectare.

RESULTS AND DISCUSSION

Results

Before storage, the seeds were subjected to preliminary testing to determine their germination rate. Preliminary testing showed that the seeds had a germination rate of 90%. Preliminary testing showed that the soybean seeds used in this study were of good quality.

In this experiment, observations were made on seed quality parameters, including moisture content, seed weight, germination capacity, germination time, germination uniformity, and yield, as follows:

Moisture content

Analysis of variance shows an interaction between the rice husk content and storage duration treatment factors. The effect of each factor shows that the rice husk content treatment has no significant effect, whereas the storage duration treatment significantly affects soybean seed moisture content.

Further testing using Duncan's test showed that the moisture content of soybean seeds after 16 weeks of storage at a 50% rice husk content treatment remained lower than that of other storage periods (Table 1).

Sprout weight

Analysis with 5% variance indicates an interaction between the rice husk content and storage duration treatment factors. The effect of each factor shows that the rice husk content treatment has no significant effect, whereas the storage duration treatment significantly affects soybean seed moisture content.

Further testing with Duncan's test showed that soybean seeds stored for 16 weeks in the rice husk percentage treatment had lower sprout weight than the other treatments (Table 2).

Germination capacity

Analysis of variance showed no interaction between the rice husk percentage and storage duration treatment factors. The effect of each factor showed that the rice husk percentage treatment had no significant effect, whereas the storage duration treatment significantly affected soybean seed germination capacity.

Further testing with Duncan's test showed that the germination capacity of soybean seeds after being stored for 16 weeks at a rice husk percentage treatment with a storage period of 8 weeks showed that the soybean seeds remained good and were still above the minimum germination rate limit for quality soybean seeds and higher than the germination rate of other treatments (Table 3).

Germination time

Analysis of variance showed no interaction between the rice husk factor and the storage duration factor. The effect of each factor showed that the desiccant type treatment had no significant effect, whereas the storage duration treatment significantly affected soybean seed germination time.

Table 1. Effect of rice husk and storage time on the water content (%) of soybean seeds

rice husk content	storage period (weeks)			
	4	8	12	16
without rice husk	10,66 a A	9,71 a C	10,76 c A	10,22 b B
25% rice husk	9,23 b B	9,25 ab B	12.32 b A	12,41 a A
50% rice husk	8,43 c C	9,15 b B	13,56 a A	8,13 c C

Note: Mean values followed by the same capital letter indicate no significant difference in the horizontal direction, while mean values followed by lowercase letters indicate no significant difference in the vertical direction based on Duncan's test at the 5% level.

Table 2. Effect of rice husk and storage time on sprout weight (g)

rice husk content	storage period (weeks)			
	4	8	12	16
without rice husk	249.52 b C	259.58 b B	266.26 b B	272.18 a A
25% rice husk	272.37 a A	267.08 a B	277.42 ab A	269.38 b B
50% rice husk	274.43 a A	269.27a B	287.63 a A	258.71 c B

Note: Mean values followed by the same capital letter indicate no significant difference in the horizontal direction, while mean values followed by lowercase letters indicate no significant difference in the vertical direction based on Duncan's test at the 5% level.

The results of Duncan's multiple-range test showed that soybean seeds stored for 16 weeks in a plastic bag with a 4-week desiccant treatment germinated in about 2 days, compared with 8, 12, and 16 weeks of storage (Table 4).

Table 3. Effect of rice husk and storage time on soybean seed germination

Treatments	Germination percentage (%)
rice husk content	
without rice husk	91.15 a
25% rice husk	92.23 a
50% rice husk	94.65 a
Storage period	
4 weeks	96.12 a
8 weeks	92.22 ab
12 weeks	90.63 b
16 weeks	78.55 c

Note: The average values followed by the same letter do not differ significantly according to Duncan's test at the 5% level.

Table 4. Effect of rice husk and storage time on the average germination time of soybean seeds

Treatments	Germination time (days)
rice husk content	
without rice husk	3.37 a
25% rice husk	3.64 a
50% rice husk	3.67 a
Storage period	
4 weeks	2.84 b
8 weeks	3.25 b
12 weeks	3.42 b
16 weeks	4.46 a

Note: The average values followed by the same letter do not differ significantly according to Duncan's test at the 5% level.

Uniformity of germination

Analysis of variance at the 5% level showed an interaction between the rice husk percentage and storage duration treatment factors. The effect of each factor showed that the rice husk percentage treatment had no significant effect, whereas the storage duration treatment significantly affected soybean seed germination uniformity. The results of Duncan's multiple range test showed that the germination uniformity of soybean seeds after being stored for 16 weeks in the 4-week storage treatment was higher than the germination uniformity of soybean seeds in the 8, 12, and 16-week storage treatments (Table 5).

Table 5. Effect of rice husk and storage time on the average simultaneity of soybean seed germination

Treatments	Simultaneous germination (%)
rice husk content	
without rice husk	84.12 a
25% rice husk	85.47 a
50% rice husk	86.52 a
Storage period	
4 weeks	89.47 a
8 weeks	83.16 ab
12 weeks	79.25 b
16 weeks	67.47 c

Note: The average values followed by the same letter do not differ significantly according to Duncan's test at the 5% level.

Yield per plant and yield per hectare

Analysis of variance at the 5% level showed no interaction between the rice husk percentage and storage duration treatment factors on yield. The effect of each factor showed that the rice husk percentage treatment factor had no significant effect, while the storage duration treatment had a significant effect on yield. Further testing with Duncan's test showed that soybean yields after 4 and 8 weeks of storage were the highest among the treatments (Table 6).

Discussion

The results of the experiment showed that there was an interaction between rice husk percentage and storage time on water content and seed weight after storage. This shows that the type of sealed plastic bag packaging for soybean seeds stored for 16 weeks maintained a low water content. This was caused by the maximum room temperature of around 28.5˚C and humidity of around 65% in the seed storage room (Septiana et al., 2025). Room air humidity is affected by the storage room's temperature; the higher the temperature, the lower the air humidity due to water activity in the air (Orkić et al., 2025).

Table 6. Effect of rice husk and storage time on seed weight per plant and yield per hectare

Treatments	Seed weight (g)	Yield (t/ha)
rice husk content		
without rice husk	16.75 a	2.144
25% rice husk	17.22 a	2.204
50% rice husk	17.47 a	2.236
Storage period		
4 weeks	18.47 a	2.364
8 weeks	18.26 a	2.337
12 weeks	17.25 b	2.208
16 weeks	16.47 c	2.108

Note: The average values followed by the same letter do not differ significantly according to Duncan's test at the 5% level.

In this experiment, this occurred primarily when storing seeds at 50% rice husk. This condition is caused by the hygroscopic nature of seeds and their tendency to reach equilibrium with environmental conditions. Changes in seed moisture content will continue until equilibrium is reached. Equilibrium moisture content is the balance between water content and environmental humidity. Relative humidity indirectly affects seed quality (Chien et al., 2020). This is also stated by Irwan et al. (2024): water content is the factor that most influences seed deterioration; seed deterioration increases with increasing water content.

Harrington's Law describes the relationship between moisture content and storage temperature on seed shelf life: for every 5°C decrease in storage temperature, seed shelf life doubles; for every 1% decrease in seed moisture content, seed shelf life doubles. This law applies when the relative humidity of the storage room ranges from 15% to 70%, the temperature is between 0 °C and 30 °C, and the seed moisture content is between 4% and 14% (Ari and Triani, 2025).

Soybean seed quality deterioration increases during storage. This is because soybean seeds continue to respire during storage. The products of respiration in stored seeds are heat and water vapor. The resulting water vapor increases seed weight after storage (Irwan et al., 2024). Increased seed moisture content correlates with increased stored seed weight; the pattern of seed weight changes is shown in Table 2.

In this experiment, soybean seeds germinated for 8 weeks had good quality, still germinated at a high rate above 80%, and had a normal, high germination rate, but were significantly different from those stored for 12 and 16 weeks. Soybean seeds stored for 16 weeks had low germination below the seed quality standard of 80%. Seed deterioration is a decrease in seed viability that results in reduced seed vigor, poor germination, and decreased yields. One process in seed deterioration is a decrease in germination rate and seed storage capacity (Damanik and Pudjihartati, 2023). The deterioration of soybean seeds during storage occurs more quickly than that of other plant seeds, leading to rapid loss of seed vigor and decreased germination.

Irwan et al. (2024) stated that soybean seeds stored with a water content of 6% and 8% for 4 months at a temperature of 150˚C have a germination percentage above 70%; and a refrigerated room (temperature 18-20˚C, RH 50-60%) can maintain seed germination of more than 85% for 1 year. At 15˚C, soybean seeds with a 12% water content can maintain a germination capacity of more than 85% for 2 years. If soybean seeds are stored at 10˚C, their germination capacity can be maintained above 85% for 3 years, while at 5˚C it can be maintained above 85% for 5 years.

Furthermore, Irwan et al. (2024) found that soybean seed germination declines from an initial germination rate of above 90% to 0%, depending on the seed species and moisture content during storage. Constraints in soybean seed storage include rapid seed deterioration and a short shelf life, due to their relatively high fat and protein content. Storing seeds until the next planting season reduces viability and vigor.

Seed storage with low water content (areas that are at and below the water content in balance with RH 65%) is very good for seed storage, because metabolic reactions and enzyme activity in the seeds run very slowly, as well as respiration runs so slowly that its rate is almost unmeasurable, but the process will stop if the seeds are completely dead (Houi, X., 2025). This means that low water content is a very important factor in seed inactivation. Seed water content greatly affects seed viability. Storing soybean seeds with low water content maintains seed viability, but in this experiment, seed viability decreased after 16 weeks of storage due to deterioration.

The effect on yield did not show any interaction effect. The rice husk treatment showed no difference, whereas the storage duration treatment showed a significant effect. The longer the seeds were stored, the lower the yield, with storage for 4 and 8 weeks showing the best effect. Research on the effect of storage duration on the yield of soybean plants stored in airtight containers (Ermawati et al., 2025).

CONCLUSION

Based on the study's results, it can be concluded that there is an interaction between the percentage of rice husks and storage duration on the moisture content and dry weight of soybean seeds. The viability and vigor of soybean seeds over 16 weeks showed no difference in response to rice husk percentage treatment. Storage duration showed differences; the longer the seeds were stored, the greater the decrease in viability, vigor, and yield. The best treatment was found in 4 weeks storage with 50% rice husk. This means that using rice husks as a mixture or storage medium for soybean seeds at various percentages did not affect seed viability or vigor after 16 weeks of storage. Regardless of the amount of rice husk used, soybean seed viability and vigor remained unchanged, indicating that rice husk was not a determining factor in reducing or maintaining seed quality during this storage period.

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