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Study of Types of Packaging Materials and Storage Temperature on The Quality of Soybean Seeds (*Glycine max* L. Merrill)

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ABSTRACT

The quality of soybean seeds, encompassing physical, physiological, and chemical attributes, is crucial for successful plant growth and yield. Effective seed storage is vital in maintaining seed viability, growth capacity, and adaptability, especially amid global challenges like climate change and rising food demand. This research aimed to identify the optimal packaging material and storage temperature to preserve soybean seed quality. Using a Split Plot Design with two factors and three replications, the study examined four storage temperatures (S0: 27.1°C, S1: 7-10°C, S2: 17-19°C, S3: 20-25°C) and three packaging types (K1: plastic-coated sack, K2: PE plastic, K3: aluminum foil). Results indicated that seeds stored at 27.1°C in plastic-coated sacks experienced increased moisture, reduced vigor, slower growth, lower germination, and altered protein and fat content. Conversely, PE plastic and aluminum foil packaging maintained seed quality over three months. All packaging types effectively preserved seed quality at cooler temperatures (7-25°C). This study underscores the importance of optimal storage conditions for sustainable soybean seed availability.

1. INTRODUCTION

The study of the impact of packaging materials and storage room temperature on the quality of soybean seeds (*Glycine max* L. Merrill) is crucial for seed preservation and viability. Research has shown that coated packaging can help in preserving the physiological quality of soybean seeds, with a more significant effect observed at ambient temperatures compared to cold environments (Coradi *et al*., 2020). Additionally, seed moisture content (SMC) plays a vital role in determining seed quality during storage (Bakhtavar *et al*., 2019). Studies have also demonstrated the importance of packaging and environmental conditions in maintaining seed quality over different storage periods (Capilheira *et al*., 2019). Furthermore, the choice of packaging materials directly influences seed viability and vigor, highlighting the need for appropriate selection of packaging materials to maintain seed quality (Farhana & Fajrina, 2022).

Storage containers and packaging materials are essential factors in influencing the longevity of seeds during storage (Shree, 2022). Interactive effects of seed moisture content and packaging material can impact seed quality and subsequent yield components (Adjei *et al*., 2022). Proper packaging is crucial in minimizing seed spoilage rates and regulating water content during storage, which are key factors in preserving seed quality over time (Oluseyi & Akinloye, 2023). Soybean seed is an important commodity in the agricultural industry, acting as a source of food and feed that affects crop production. Soybean seed quality, including physical, physiological and chemical aspects, determines the success of growth and yield. Seed storage is a crucial stage in the distribution chain, affecting plant viability, growth capacity and adaptability.

In tropical regions like Indonesia, soybean seeds have low storability due to high hygroscopic properties (Rosyadita *et al*., 2023). Many breeders use plastic sacks for storage, often neglecting temperature control, leading to production instability and market scarcity (Wulandari & Setiono, 2022). Packaging materials and storage temperature affect relative humidity, ventilation, air permeability, and light, all crucial for seed viability. Modern storage technologies, such as refrigeration and data recorders, can help maintain optimal conditions and extend seed shelf life (Ermawati *et al*., 2022). This study aims to identify the most effective packaging type and storage temperature to inhibit soybean seed quality deterioration, improving storage management and sustainable seed availability.

Currently, many seed breeders use plastic sacks for storage because they are cheap and readily available, but often neglect the temperature of the storage room due to limited knowledge and facilities. As a result, soybean seeds are not available throughout the year, only in certain harvest seasons, causing production instability and scarcity in the market which triggers price increases and increased imports (Wulandari & Setiono, 2022). The type of packaging material and storage temperature greatly affect relative humidity, ventilation, air permeability and light, all of which play a role in maintaining seed viability. Too high a temperature accelerates seed respiration and metabolism, while too low a temperature can damage seed tissue. Modern storage technologies, such as refrigeration systems and temperature and humidity data recorders, can help maintain optimal conditions and extend the shelf life of seeds (Nurmauli *et al*., 2022). This study aims to determine the most effective packaging type, storage temperature and their combination to inhibit the deterioration of soybean seed quality during storage, in order to improve storage management and maintain sustainable seed availability.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this study were Anjasmoro soybean seeds, Anjasmoro were collected from soybean growing regions in West Java (Sutrawati *et al*., 2021), plastic-lined sacks, PE plastic, aluminum foil, distilled water, label paper, sticker paper and polybags. While the equipment included digital temperature and humidity recording device with data logger, oven, analytical scale, 620 gram capacity scale, grinder, aluminum cups, desiccator, tweezer, paddle, and conductivity meter.

2.1. Design of Experiment

This study used a Divided Plots Design with 2 (two) factors. The first factor was storage temperature consisting of four storage temperatures, namely S0 = producer warehouse temperature as control, S1 = temperature 7-10 °C (using a cooler), S2 = storage temperature 17-19 °C (using an AC), and S3 = storage temperature 20-25 °C (using an AC). The second factor was the type of packaging material, consisting of 3 packaging material types, namely K1 = plastic-lined sack packaging, K2 = packaging, and K3 = Aluminum foil packaging. With 3 (three) replications, all treatment combinations resulted 36 experimental units those were arranged as shown in Figure 1.

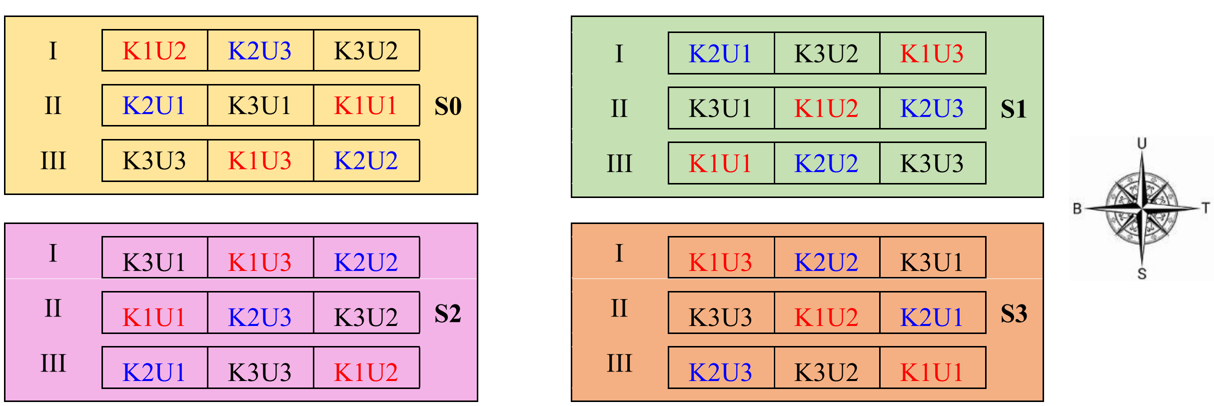

Figure 1. Experimental arrangement of the storage room (S = storage temperature, K = packaging type, U = replication)

2.2. Packaging

Research seeds were received from certified producers with superior seed certificates and labeled for distribution (BR class), totaling 30 kg. The seeds were homogenized by thorough mixing, then 800 g were weighed and packed into plastic-lined sacks, 80-micron PE plastic, and aluminum foil. Each packaging type constituted of 12 packages, which were then sealed and labeled according to the treatment.

2.3. Storage

The storage setup included a control warehouse with no temperature adjustment, a cooler set at 7-10 °C, and air-conditioned rooms set at 17-19 °C and 20-25 °C. Temperature and humidity were recorded using and stored in a data logger. Nine seed packs—three each of plastic-lined sacks, 80-micron PE plastic packs, and aluminum foil packs—were placed in each storage room.

2.4. Initial Analysis of Seed Quality

The initial analysis of soybean seed quality for research involved collecting 1000 g of certified, superior-class (BR) soybean seeds from producers. Eight parameters were tested: moisture content, germination, vigor index, growth rate, electrical conductivity, carbohydrate content, fat content, and protein content (Widajati *et al*., 2023). Moisture content, germination rate, vigor index, growth rate, and electrical conductivity were tested at the UPT PSBTPH laboratory in East Java. Moisture content was measured using the oven method (2 replicates), while germination, vigor index, and growth rate were assessed using the sand method (4 replicates of 100 seeds each). Electrical conductivity was tested with a conductivity meter (4 replicates of 50 seeds each). Carbohydrate, fat, and protein content were analyzed at the Food Quality and Safety Testing Laboratory of Brawijaya University, Malang.

2.5. Growing Test

The soil for planting media was collected from Gayung Kebonsari, Surabaya. Before planting, the soil was mixed with compost at a ratio 1:1 to maintain moisture and facilitate seed imbibition. Pot trials were performed using polybags sizing of 25×25 cm with arrangement as depicted in Fibure 2. Spacing between polybags was 25 cm and each pot was planted with 3 seed of soybean. Plants was watered twice daily (morning and evening) using a small paddle to ensure adequate water for soybean plants. Weeding was performed manually by hand to remove weeds around the soybean plants. Pest control was conducted by mechanically removing pests directly from the plants. The experiment was terminated at approximately 20 days after sowing. The plants were carefully uprooted, and both wet and dry weights are measured for each treatment.

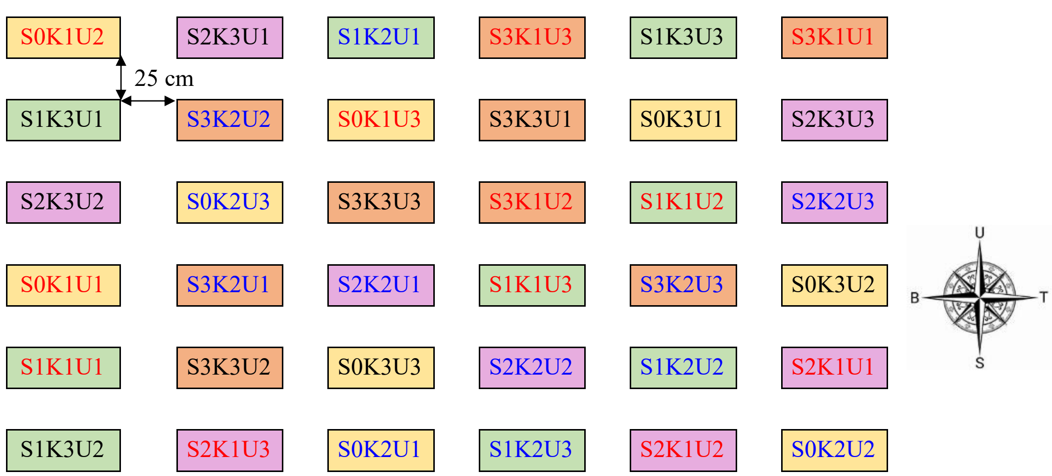

Figure 2. Field experiment arrangement

2.6. Water Content

Moisture content of soybean seed was determined using oven method (130 °C) for 1 hour, each sample with 2 replicates. Seed moisture content was calculated using the following formula (Kementerian Pertanian, 2021):

$$\text{KA}\ (\%) = \frac{\text{M2}-\text{M1}}{\text{M2}-\text{M3}} x 100\% \tag{1}$$

where M1 is the weight of empty cup, M2 is the weight of cup + sample before drying, abd M3 is weight of cup + sample after drying

2.7. Vigor Index

The vigor index was measured based on the percentage of the normal sprouts on the first observation day, namely day 5 after planting. The vigor index was calculated using the following formula (Lesilolo *et al*., 2013):

$$\text{IV}\ (\%) = \frac{\sum \text{Normal Sprouts Day 5}}{\sum \text{Planted seeds}} x 100\% \tag{2}$$

2.8. Growth Rate

Growth rate (%/ethmal) was calculated every day for 8 days on seeds that grew normally. Calculation by summing up the results of the division between the percentage of normal sprouts that grow at each observation with the observation time. The growth rate is measured by the following formula (Lesilolo *et al*., 2013):

$$\text{KCT} = \left(\% \frac{KN}{ethmal}\right) = \sum_0^{\text{tn}} \frac{\text{N}}{\text{t}} \text{x}100\% \tag{3}$$

where t_i is the i^{th} observation time, N is percentage of normal sprouts at each observation time, t_n is final observation time (day 8). It should be noted that 1 ethmal = 1 day.

2.9. Germination Power

Germination was calculated based on the number of normal sprouts on the first observation day at 5 days after planting and the second observation at 8 days after planting. Germination power was calculated using the following formula (Kementerian Pertanian, 2019):

$$\text{DB}\ (\%) = \frac{\sum \text{Normal Sprouts}}{\sum \text{Planted seeds}} x 100\% \tag{4}$$

2.10. Electrical Conductivity (EC)

Soybean seeds that have been soaked in ion-free water (aquadest) at 20°C for 24 hours are measured for electrical conductivity with a conductivity meter. Each sample was 4 replicates. Measurement begins with measuring the blank solution and then the sample seed solution. Calculation for each replicate using the following formula (Kementerian Pertanian, 2021):

$$\text{Conductivity} = \frac{\text{Seed conductivity} - \text{Blank conductivity}}{\text{Sample weight}} \tag{5}$$

2.11. Analysis of Seed Biochemical Content

Biochemical content analysis carried out includes analysis of the content of food reserves (carbohydrates, fat and protein) by sending seed samples that have been stored for 3 months (final observation) to the Food Quality and Safety Testing Laboratory, Brawijaya University Malang. The fat content was analyzed using the Soxhlet Extraction method with non-polar solvents (BSN, 1992). The protein content was analyzed using the Kjeldahl method, converting nitrogen compounds to ammonium sulfate, then decomposing with NaOH and binding ammonia with boric acid (BSN, 1992). The carbohydrate content was calculated using the by difference method (Aly *et al*., 2023):

$$\text{Carbohydrate} = 100\% - \%\ (\text{protein} + \text{fat} + \text{water} + \text{ash}) \tag{6}$$

2.12. Plant Height

Plant height was measured at the end of the observation (± 20 days after planting) from the ground surface to the growing point using a 100 cm measuring tape.

2.13. Root Length

Root length was measured from the uppermost root growth point to the lowest using a 100 cm measuring tape, recorded in the plant height observation table.

2.14. Wet Plant Weight

Wet plant was weighed using a digital scale (620 g capacity) after harvesting, recording the weight of whole soybean plants (with roots) per polybag.

2.15. Dry Plant Weight

Plants (with roots) were dried at 60 °C until reaching a constant weight, then weighed using a digital scale (620 g capacity) and recorded.

2.16. Data Analysis Method

Data were tabulated and analyzed using ANOVA and further tested with Duncan Multiple Range Test (DMRT) at the 5% level, processed with Ms. Excel and SPSS 26.0 software.

3. RESULTS AND DISCUSSION

The average temperature of the storage room downloaded from the temperature and humidity measuring device (thermohygrometer data logger) placed in each storage room during the storage period is shown in Table 2. It shows the average storage temperature over the 3-month period remained within the set range, despite daily fluctuations that are influenced by external temperatures. The rising outside temperatures significantly impact air conditioner performance (Khuluza *et al*., 2023). Each degree of increase in outside temperature reduces cooling power, refrigerant circulation, and the coefficient of performance (CoP), while increasing compressor power and electrical energy consumption (Ovca *et al*., 2021).

Table 2. Temperature and humidity (RH) data of the testing room during the storage period (3 months)

Storage Room / Setting Temperature	Average Temperature (°C)				Average RH (%)			
	Month 1	Month 2	Month 3	Average	Month 1	Month 2	Month 3	Average
S0	27.9	26.8	26.5	27.1	68.2	75.4	74.9	72.8
S1 (7-10°C)	8.3	6.8	6.8	7.3	14.8	14.1	14.4	14.4
S2 (17-19°C)	17.9	18.3	18.3	18.2	64.3	64.4	64.2	64.3
S3 (20-25 °C)	22.2	23.9	23.6	23.2	56.8	67.2	66.9	63.7

3.1. Effect of Treatment on the Physical Quality of Soybean Seeds

The physical quality of seeds is reflected in the seed moisture content data which shows the content of moisture content in seeds expressed in percent (Coradi, Lima, Padia, *et al*., 2020). The average seed moisture content before storage and during the storage period can be seen in the Table 3. The table shows the average initial seed moisture content (before storage) and the average seed moisture content of the 1st month after storage are still relatively the same in all treatment combinations.

Table 4 show the results of ANOVA analysis followed by DMRT test showed that soybean seeds in plastic-lined sacks stored at 7-10 °C (S1K1) had the lowest moisture content of 8.3%, while those stored in the producer warehouse (control) at 27.1°C/72.8% (S0K1) had the highest moisture content of 11.0%. This moisture content is the maximum

Table 3. Average seed moisture content before storage and during the storage period

Sample Code	KA Average (%)			Sample Code	KA Average (%)		
	Month 1	Month 2	Month 3		Month 1	Month 2	Month 3
Initial KA	**9.7**						
S0K1	9.8	10.6	11.0	S2K1	9.8	9.8	9.7
S0K2	9.8	9.9	9.9	S2K2	9.9	9.8	9.8
S0K3	9.8	9.9	9.8	S2K3	9.8	9.8	9.7
S1K1	9.6	9.1	8.3	S3K1	9.7	9.9	9.8
S1K2	9.3	9.7	9.6	S3K2	9.7	9.8	9.8
S1K3	9.8	9.8	9.6	S3K3	9.8	9.8	9.7

Table 4. Duncan test (DMRT) result on the effect of treatments on water content of soybean seeds

Packaging type (K)	Storage temperature (S)			
	S0	S1	S2	S3
K1	11.0 e	8.3 a	9.7 bc	9.8 c
K2	9.9 d	9.7 bc	9.8 c	9.8 c
K3	9.8 c	9.6 b	9.7 bc	9.7 bc

limit in the soybean seed quality specification that relevant with studies by (Andini *et al*., 2022; Bareke *et al*., 2022; Kementerian Pertanian Republik Indonesia, 2022). Plastic sacks that are not tight allow outside air to enter, causing fluctuations in moisture content. Seed moisture content is influenced by the humidity of the storage room; seeds absorb or release water vapor according to the surrounding relative humidity (Hay *et al*., 2023; Nasrullah *et al*., 2021). Porous packaging can cause RH changes and water condensation, increasing seed moisture content and decreasing viability (Capilheira *et al*., 2019). In contrast, airtight packaging such as aluminum foil or laminated plastic keeps storage conditions more stable, prevents excess moisture, and reduces the risk of pathogen infestation (Bewley *et al*., 2013; Lamberti & Escher, 2007; Tatipata, 2010).

Table 5. Vigor index, growth rate, germination rate and electrical conductivity at the beginning and after storage for 3 months

No	Observation Parameters				
	Sample Code	IV (%)	KCT (%)	DB (%)	DHL (µS/cm)
	Initial Data	**74**	17	84	28.66
1	S0K1	43	14	75	31.59
2	S0K2	43	14	80	30.58
3	S0K3	45	14	79	29.96
4	S1K1	55	16	83	29.07
5	S1K2	55	16	84	29.00
6	S1K3	56	15	82	28.78
7	S2K1	55	16	84	28.42
8	S2K2	55	15	81	27.85
9	S2K3	54	15	83	27.73
10	S3K1	52	15	82	27.94
11	S3K2	55	15	81	27.50
12	S3K3	61	16	85	28.37

3.2. Effect of Treatment on Physiological Quality of Seeds

The physiological quality of seeds is reflected in the data of vigor index, growth rate, germination and electrical conductivity. The average vigor index, growth rate, germination and electrical conductivity and after being stored for 3 months can be seen in the following Table 5. Table 5 shows that the vigor index and growth rate of soybean seeds decreased after 3 months of storage, with the sharpest decrease at the control temperature in the producer's warehouse for all types of packaging. Storage temperature has more influence on the physiological quality of seeds than the type of packaging, in accordance with previous studies (Purwanti, 2015; Koskosidis *et al*., 2022; Nasrullah *et al*., 2021; Pinandita *et al*., 2019; Ramdan *et al*., 2022). The DMRT test showed that seeds in plastic sacks in the producer's warehouse (S0K1) had the lowest germination rate (78.3%), while seeds in aluminum foil packaging at 17-19 °C (S2K3) had the highest germination rate (88.3%), but all were still within the limits of seed quality specifications Kementerian Pertanian Republik Indonesia, 2022). Germination, vigor index, and growth rate are the main indicators of seed quality. Decreased germination is caused by oxidative damage and enzymatic degradation. Vigor index and sprouting rate are affected by storage temperature and humidity; high temperatures accelerate respiration and degradation of essential components, reducing seed quality (Bewley *et al*., 2013; Filho, 2015). Electrical conductivity (DHL) values increased at the control temperature in the producer's warehouse, indicating greater cellular damage. DHL is negatively correlated with germination; seeds with high DHL show greater cell membrane damage (Matthews & Powell, 2012; Mavi *et al*., 2014; Nugraheni *et al*., 2023). High temperatures accelerate cell degradation and electrolyte leakage, while low temperatures slow down these processes, maintaining cell membrane integrity for longer (Copeland & McDonald, 2001; Filho, 2015; Matthews *et al*., 2002; Niu & Xiang, 2018).

3.3. Effect of Treatment on Chemical Properties of Seeds

Table 6 shows that the initial protein content in all treatment combinations decreased after 3 months of storage, while the fat content increased and the carbohydrate content tended to stabilize. Seeds continue to undergo metabolic processes even in dormant conditions. The decrease in protein is caused by protein degradation by protease enzymes, which convert proteins into amino acids or peptides. These amino acids can be used in metabolic reactions or stored as fat through lipogenesis if environmental conditions are favorable (Bewley *et al*., 2013). The increase in fat occurs because the metabolic pathway that converts amino acids to acetyl-CoA, an important precursor in fatty acid synthesis, is more dominant under certain storage conditions (Copeland & McDonald, 2001). The stability of carbohydrates suggests that the metabolic pathways that convert carbohydrates into energy or other forms are not as active as the pathways that convert protein into fat. Carbohydrate in soybean seeds is often stored as oligosaccharide or starch, which are relatively stable and will not break down easily under good storage conditions (Filho, 2015).

Table 6. Chemical content of seeds at the beginning and after storage for 3 months

No	Seed Chemical Content			
	Sample Code	Protein	Carbohydrate	Fat
	Initial Data	**45.39**		**33.13**
1	S0K1	35.56	32.25	17.38
2	S0K2	37.89	33.38	15.24
3	S0K3	37.17	33.38	16.19
4	S1K1	38.44	33.37	16.21
5	S1K2	36.96	33.56	16.19
6	S1K3	37.17	33.57	16.03
7	S2K1	36.74	35.11	13.59
8	S2K2	37.12	35.55	14.32
9	S2K3	37.25	34.99	14.78
10	S3K1	37.21	33.10	16.47
11	S3K2	37.48	33.26	16.07
12	S3K3	37.34	32.23	16.59

Table 7 shows the treatment combination S0K1 (soybean seeds in plastic-lined sacks, stored in the producer's warehouse) has the smallest average value of 35.6, while the combination S1K1 (soybean seeds in plastic-lined sacks, stored at 7-10 °C) has the largest average value of 38.4. High temperatures increase the activity of protease enzymes that break down proteins into peptides and amino acids, accelerating protein degradation (Bewley *et al*., 2013). High temperature also increases the respiration rate of seeds, which accelerates the breakdown of proteins to meet energy requirements (Filho, 2015). In addition, high temperatures increase proteolytic microbial activity in porous packaging, which also accelerates protein degradation (Copeland & McDonald, 2001; Matthews *et al.*, 2002). The fluctuations of

Table 7. Duncan test (DMRT) result on the effect of treatments on protein content of soybean seeds

Packaging type (K)	Storage temperature (S)			
	S0	S1	S2	S3
K1	35.6 a	38.4 e	37.0 b	37.2 bc
K2	37.9 d	37.1 bc	37.2 bc	37.5 cd
K3	37.2 bc	37.2 bc	37.2 bc	37.3 bcd

humidity at high temperatures can cause osmotic stress and increase hydrolytic enzyme activity, accelerating protein degradation (Kieliszek *et al*., 2021). In contrast, low temperatures reduce protease enzyme activity, respiration rate and microbial growth, thus slowing down protein degradation and maintaining protein stability in the seed (Yang *et al*., 2023).

Table 8 shows the treatment combinations S3K3, S0K1, S3K1, S3K2, S1K1, S0K2, S0K3 have subset a different from other treatments, indicating that there is a significant difference and has the smallest average value, while the S2K1 S2K2 treatment combination has subset f different from other treatments, it indicates that there is a significant difference and has the largest average value (Bewick *et al*., 2004).

Table 8. Duncan test (DMRT) result on the effect of treatments on carbohydrate content of soybean seeds

Packaging type (K)	Storage temperature (S)			
	S0	S1	S2	S3
K1	32.3 a	33.4 a	35.1 c	33.1 a
K2	33.4 a	33.6 ab	35.6 c	33.3 a
K3	33.4 a	33.6 ab	35.0 bc	32.2 a

Table 9. Duncan test (DMRT) result on the effect of treatments on fat content of soybean seeds

Packaging type (K)	Storage temperature (S)			
	S0	S1	S2	S3
K1	17.4 e	16.2 bcd	13.6 a	16.5 bcd
K2	15.2 bc	16.2 bcd	14.3 ab	16.1 bc
K3	16.2 bcd	16.0 bc	14.8 b	16.6 de

Table 9 shows the S2K1 treatment combination, namely soybean seeds in plastic-lined sacks, stored at a temperature of 17-19 °C, has a significant difference and has the smallest average value of 13.6 while the S0K1 treatment combination, namely soybean seeds in plastic-lined sacks, stored in the producer's warehouse (control) has a different subset e with other treatments, it indicates that there is a significant difference and has the largest mean value of 17.4, this is a natural mechanism caused by enzymatic activity that causes a decrease in protein levels so as to increase the fat content in seeds.

3.4. Effect of Treatment on Vegetative Phase Growth of Soybean Plants

Table 10 shows plant observation on vegetative phase parameters showed no significant differences in all treatment combinations, possibly because soybean seeds can adapt to existing storage conditions. As long as storage conditions do not reach extremes that damage seed integrity, seeds are still able to germinate and grow well (Bewley *et al*., 2013). Environmental factors after planting, such as the quality of the growing medium, water, nutrients, light, and agronomic management, are more dominant in determining the vegetative growth of soybean plants (Filho, 2015). Short storage duration may not be significant enough to drastically affect seed quality, as short-term storage usually does not cause sufficient degradation of seed components to affect vegetative growth (Choudhury & Bordolui, 2023; Corbineau, 2024; Gebeyehu, 2020).

Table 10. Plant observation data on vegetative phase in polybags

No	Observation Parameters				
	Sample Code	**Plant Height (cm)**	**Root Length (cm)**	**Wet Weight (g)**	**Dry Weight (g)**
1	S0K1	37.00	14.27	4.88	0.78
2	S0K2	38.37	15.83	4.99	0.55
3	S0K3	33.17	13.83	6.77	1.66
4	S1K1	34.00	12.77	3.79	0.79
5	S1K2	35.23	13.83	4.22	0.90
6	S1K3	34.43	15.00	3.42	0.77
7	S2K1	35.87	12.67	4.17	0.69
8	S2K2	34.77	12.93	4.34	0.84
9	S2K3	32.90	12.83	3.63	0.69
10	S3K1	38.33	14.37	4.87	0.91
11	S3K2	33.77	14.30	3.65	0.77
12	S3K3	36.20	14.60	3.87	0.84

4. CONCLUSION

The combination of plastic-lined sack packaging and the control storage room temperature treatment in the warehouse of seed producer without air conditioning equipment with an average temperature of 27.1 °C and RH of 72.8% recorded from the temperature/humidity recorder caused a significant increase in moisture content, followed by a decrease in vigor index, growth rate, germination rate, and protein content, as well as an increase in electrical conductivity and fat content in seeds. In contrast, the PE plastic and aluminum foil packaging material treatments were able to maintain seed quality during the 3-month storage period. In addition, the combination of storage temperature treatments S1 (7-10 °C), S2 (17-19 °C), and S3 (20-25 °C) with all types of packaging materials was also able to maintain seed quality for 3 month storage period.

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