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The Effect of Various Seed Coating Materials on the Growth of Soybean (*Glycine max* L. Merrill) Seeds after 3 Months of Storage

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Abstract

Efforts to improve the quality of the Anjasmoro soybean variety (Glycine max L. Merrill) include the use of seed coating techniques. Seed coating involves applying a layer of specific materials to seeds, serving as carriers for additional substances that extend seed shelf life, protect against pathogens, and stimulate plant growth. This study aimed to identify the most effective seed coating material to enhance soybean growth after storage for three months. Growth tests were conducted using the following treatments: FP 0 (control); FP 1 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 g + Gypsum 18 g); FP 2 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 g + Talc 18 g); FP 3 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 g + Pumice stone 18 g); FP 4 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 g + Quicklime 18 g); FP 5 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 g + Dolomite 18 g); and FP 6 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 g + Zeolite 18 g). Observations included plant height (cm), number of leaves, and number of branches. The study was conducted from April to October 2024 at the UPT Center for Rice and Secondary Crops Seed Development 2, Singosari District, Malang, using a randomized block design (RAK) with seven formulations of seed coating materials. Each treatment consisted of 16 plants with four replications. The research data were analyzed using ANOVA, followed by a BNJ (Honestly Significant Difference) test at the 5% significance level (BNJ 0.05). The results showed that the FP 1 treatment resulted in a plant height of 56.50 cm, 19.75 leaves, and 4.75 branches at 35 days after planting (DAP). The FP 1 treatment significantly enhanced growth, as indicated by plant height, leaf number, and branch number. FP 1 demonstrated the best combination of seed coating materials compared to other treatments at 21, 28, and 35 DAP

Keywords: Anjasmoro Variety, Coating, Gypsum, Seeds, Shelf Life

1. Introduction

Soybeans (*Glycine max* L. Merrill) are a strategic food commodity in Indonesia due to their high demand as a protein source and as a raw material for various processed products. However, national soybean demand remains highly dependent on imports, indicating a gap between domestic production and consumption. One important factor influencing soybean productivity is the quality of the seeds used. In practice, maintaining seed quality during storage remains a major challenge, as soybean seeds are highly susceptible to physiological deterioration, which reduces viability and vigor.

The process of seed deterioration is irreversible and is influenced by temperature, seed moisture content, and the relative humidity of the storage area. Although deterioration cannot be stopped, its rate can be slowed through certain treatments. One technology developed for this purpose is *seed coating, a technique that coats seeds with exogenous materials that serve* as carriers of active substances. According to Palupi *et al.* (2012), *seed coating* can improve germination performance, provide protection against unfavorable environmental conditions, stabilize seed moisture content, and extend shelf life. Zeng and Zhang (2010) also reported that seed coating on soybeans can increase yields by up to 17.95% at a cost-effective rate compared with conventional seed preparation methods. According to Putri and Majid (2019), seed coating can enlarge seeds to 3-4 mm in diameter by using ingredients

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that improve plant performance. *This study used a concentration of* $_{CaCO3}$ additives. 72 grams, more than 18 grams of gypsum, talc, pumice, quicklime, dolomite, and zeolite. This concentration uses a 4:1 ratio, whereas previous research used a 1:4 ratio.

Seed coating technology in the seed industry is considered highly effective. This functionality stems from its ability to improve seed appearance, extend shelf life, and reduce the risk of disease transmission from surrounding seeds. Furthermore, *seed coating* serves as a carrier for various additives, including antioxidants, antimicrobials, antagonistic microbes, and growth regulators. Overall, this technique aims to maintain the physiological quality of seeds and protect them from adverse environmental influences (Yulia et al., 2019).

Seed coating has been widely applied to various plant species, particularly horticultural crops, to extend shelf life, protect against pathogens, stimulate early growth, and improve germination uniformity. The effectiveness of seed coating largely depends on the type of coating material used. For example, carboxymethyl cellulose (CMC) can form a stable, uniform coating, providing enhanced protection during storage. However, prolonged storage may increase seed moisture content, ultimately affecting their viability.

Research on seed coatings for soybeans remains limited, especially regarding the comparative effectiveness of different coating materials in preserving seed quality during storage. Therefore, this study was conducted to evaluate the effects of various seed-coating formulations on soybean seed growth after 3 months of storage.

2. Material and Methods

The research was conducted from April to October 2024 at the experimental field of the UPT Rice and Secondary Crops Seed Development Center 2, Kec. Singosari, Malang (Latitude -7.86946, Longitude 112.68033), at an altitude of 487 meters above sea level, with an average temperature of 22–32°C and humidity ranging from 40% to 70%. The equipment and materials used included a rotary coater, petri dishes, glass bottles, polybags, rulers, soybean seeds (*Glycine max* L. Merrill) for seed coating, NPK fertilizer, pesticides, and compost, applied as needed. This study employed a Randomized Block Design (RBD) with six types of seed coating materials and seven control codes as follows: - CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of Gypsum - CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of Talc - CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of Pumice stone - CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of Quicklime - CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of Dolomite - CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of Zeolite. There were 28 experimental plots, each consisting of 4 plants with a planting distance of 25 x 25 cm. The experiment was repeated 4 times.

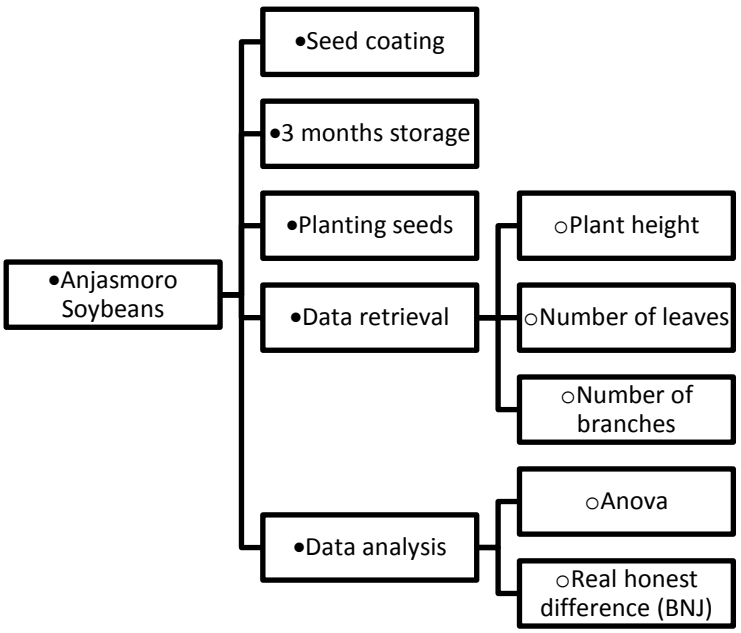

Figure 1. Research Flowchart

The research was conducted by selecting Anjasmoro soybean seeds. Seeds were visually selected based on morphological traits (shape, color, size, and outer texture) to obtain the highest-quality seeds. The seeds were coated for each formulation treatment and stored for 3 months. Planting was carried out after 3 months of storage in polybags, using a 1:1 mixture of soil and compost. The seeds were planted in perforated polybags with 4 holes each, containing 2-3 soybean seeds per treatment. Plant maintenance included watering every morning and evening,

manual weeding around soybean plants, fertilization with organic and NPK fertilizers, and pest and disease control. The parameters observed in this study are as follows:

a. Plant Height (cm)

Plant height was measured using a ruler, starting from the base of the stem above ground level to the highest growing point on each sample plant. Observations were made starting at 1 week after planting, with weekly intervals until the plants reached 8 weeks after planting, or the beginning of the generative phase.

b. Number of leaves (blades)

counts were conducted 1 week after planting, with weekly intervals until 5 weeks after planting, or until the beginning of the generative phase. Soybean leaves are trifoliate, meaning each stalk contains three leaves. Counting was only performed on leaves with less than 50% damage.

c. Number of Branches

Branch counts were performed on sample plants for each treatment. Observations began 1 week after planting, with weekly intervals until 5 weeks after planting, or until the end of the vegetative phase.

The data analysis used ANOVA followed by a BNJ (Honest Significant Difference) post hoc test at the 5% level (BNJ 0.05) using Microsoft Excel and SPSS 24.

3. Results and Discussion

3.1. Height (cm)

Seed coating treatment had a significant effect on soybean plant height at 21, 28, and 35 days after sowing, while at 7 and 14 days after sowing, it did not show a significant effect (Table 1). FP_1 treatment (1.5% CMC + 0.5% liquid smoke + 72 g $CaCO_3$ + 18 g gypsum) resulted in plants with significantly increased growth up to 35 days after sowing. These findings indicate that seed coating can increase seed vigor, thereby supporting plant vegetative development.

The data in Table 1 shows that the type of *seed coating material* significantly affected plant height parameters. FP_1 formulation produced the highest average over the first 28 days after planting. The average plant height in the FP_1 treatment was 6.13 cm (7 days after planting), 11.50 cm (14 days after planting), 21.25 cm (14 days after planting), and 36.25 cm (28 days after planting). However, at 35 days after planting, three treatments, namely FP_1, FP_6, and FP_2, showed the best performance with plant heights reaching 56.50 cm, 53.75 cm, and 53.25 cm, respectively. These results align with research by Zeng and Zhang (2010), who reported that seed coating techniques can increase plant height and overall growth performance. The effectiveness of $FP_{1\ formulation}$ is strongly suspected to be due to gypsum's role in improving soil-root interactions, thus supporting nutrient uptake and plant growth. The growth visualizations shown in Figure 2 reinforce these findings, as coated seeds produced plants that were not only taller but also had more leaves and branches.

Table 1. Average Plant Height Soybeans from *Seed Coating* with a Shelf Life of 3 Months, Age 7-35 DAP.

***Seed Coating* Material**	**Average Plant Height (cm)**				
	7 DAP	**14 DAP**	**21 DAP**	**28 DAP**	**35 DAP**
FP_0 (control)	6.75 ± 1.49	11.00 ± 0.96	17.25 ± 0.32 ab	30.75 ± 2.50 b	43.63 ± 4.34 b
FP_1 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Gypsum 18 grams)	6.13 ± 0.96	11.50 ± 1.44	21.25 ± 0.48 c	36.25 ± 0.25 c	56.50 ± 0.29 c
FP_2 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Talc 18 grams)	4.18 ± 0.91	11.50 ± 1.19	17.63 ± 2.07 b	34.88 ± 1.03 bc	53.25 ± 1.88 c
FP_3 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Pumice Stone 18 grams)	5.25 ± 0.63	9.38 ± 1.66	16.75 ± 1.09 ab	28.25 ± 3.17 ab	38.63 ± 3.56 ab
FP_4 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Quicklime 18 grams)	4.63 ± 0.32	8.75 ± 1.15	14.50 ± 0.87 a	23.38 ± 1.75 a	32.50 ± 2.48 a
FP_5 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Dolomite 18 grams)	5.13 ± 0.95	7.13 ± 1.75	15.00 ± 0.87 ab	28.13 ± 1.65 ab	38.75 ± 2.39 ab
FP_6 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Zeolite 18 grams)	5.63 ± 0.48	12.00 ± 0.71	18.78 ± 0.76 bc	35.75 ± 0.42 bc	53.75 ± 1.31 c
BNJ 5%	tn.	tn.	3.02	5.02	7.11

Description: Numbers accompanied by the same letter in the same column show no significant difference in the 5% BNJ test.

Figure 2. Visual Growth of Soybean Plants from Seed Coating Treatments FP 0 (control); FP $_1$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$) 72 grams + 18 grams of gypsum); FP $_2$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Talk18 grams); FP $_3$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of pumice stone); FP $_4$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + 18 grams of quicklime); FP $_5$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Dolomite 18 grams); and FP $_6$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Zeolite 18 grams).

3.2. Number of Leaves (Sheets)

Statistical analysis showed that the type of seed coating material significantly affected the number of soybean leaves after three months of storage, although this effect was not consistent across all observation ages. No significant differences were observed at 7 and 14 days after planting, but significant differences were observed at 21, 28, and 35 days after planting. The average number of leaves is presented in Table 2.

Table 2. Average Number of Leaves Soybeans from *Seed Coating* with a Shelf Life of 3 Months, Age 7-35 DAP.

***Seed Coating* Material**	**Average Number of Leaves (Sheets)**				
	7 DAP	**14 DAP**	**21 DAP**	**28 DAP**	**35 DAP**
FP $_0$ (control)	2.25 ± 0.25	2.75 ± 0.25	5.00 ± 0.00 ab	10.50 ± 0.87 b	13.50 ± 1.19 b
(CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Gypsum 18 grams)	2.25 ± 0.25	4.25 ± 0.48	7.00 ± 0.58 c	13.75 ± 0.86 c	19.75 ± 2.06 c
FP $_2$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Talc 18 grams)	2.25 ± 0.25	3.00 ± 0.41	5.75 ± 0.25 b	12.00 ± 0.91 bc	16.00 ± 1.47 bc
FP $_3$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Pumice Stone 18 grams)	1.75 ± 0.25	2.25 ± 0.25	5.00 ± 0.41 ab	11.00 ± 0.41 b	14.25 ± 0.75 bc
FP $_4$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Quicklime 18 grams)	2.50 ± 0.29	2.75 ± 0.25	4.00 ± 0.00 a	7.50 ± 1.19 a	9.00 ± 1.41 a
FP $_5$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Dolomite 18 grams)	2.50 ± 0.29	3.00 ± 0.41	4.50 ± 0.29 a	9.25 ± 1.03 ab	12.00 ± 1.58 a
FP $_6$ (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Zeolite 18 grams)	2.25 ± 0.25	3.50 ± 0.65	6.25 ± 0.63 bc	12.75 ± 1.11 bc	18.25 ± 2.39 c
BNJ 5%	tn.	tn.	1.05	2.31	4.23

Description: Numbers accompanied by the same letter in the same column show no significant difference in the 5% BNJ test.

Seed coating treatment significantly affected the number of leaves at 21, 28, and 35 DAP (Table 2). FP $_1$ formulation again recorded the highest yield with 19.75 leaves at 35 DAP. FP $_6$ treatment also showed a high value (18.25 leaves) and was not statistically significantly different from FP $_1$. Conversely, the control treatment (FP $_0$) and FP $_4$ (containing quicklime) recorded the lowest number of leaves. The increase in leaf number in FP $_1$ and FP $_6$ is thought to be related to the ability of gypsum and zeolite to maintain moisture balance around the seeds and provide additional nutrients essential for supporting photosynthesis. This finding confirms the findings of Palupi et al. (2012), who reported that *seed coating* can improve germination uniformity and encourage vegetative plant growth.

3.3. Number of Branches

The analysis of variance showed a significant effect of *seed coating materials* on the number of soybean branches after 3 months of storage. This effect was not visible in the initial observations (7 and 14 days after planting), but became apparent at 21, 28, and 35 days after planting. Details of the average number of branches are presented in Table 3.

Table 3. Average Number of Branches Soybeans from *Seed Coating* with a Shelf Life of 3 Months at 7-35 DAP.

***Seed Coating* Material**	**Average Number of Branches**				
	7 DAP	**14 DAP**	**21 DAP**	**28 DAP**	**35 DAP**
FP_0 (control)	0.00	0.00	1.00 ± 0.00 a	2.25 ± 0.25 a	4.00 ± 0.00 ab
FP_1 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Gypsum 18 grams)	0.00	0.00	2.50 ± 0.29 c	3.50 ± 0.29 b	4.75 ± 0.25 b
FP_2 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Talc 18 grams)	0.00	0.00	1.75 ± 0.48 b	3.50 ± 0.29 b	4.25 ± 0.48 b
FP_3 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Pumice Stone 18 grams)	0.00	0.00	1.25 ± 0.25 a	3.25 ± 0.25 b	4.00 ± 0.41 ab
FP_4 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Quicklime 18 grams)	0.00	0.00	1.00 ± 0.00 ab	2.50 ± 0.29 ab	3.25 ± 0.25 a
FP_5 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Dolomite 18 grams)	0.00	0.00	1.00 ± 0.00 a	3.00 ± 0.41 ab	3.50 ± 0.29 ab
FP_6 (CMC 1.5% + Liquid Smoke 0.5% + $CaCO_3$ 72 grams + Zeolite 18 grams)	0.00	0.00	1.75 ± 0.25 b	3.25 ± 0.25 b	4.25 ± 0.25 b
BNJ 5%	tn.	tn.	0.69	0.79	0.80

Description: Numbers accompanied by the same letter in the same column show no significant difference in the 5% BNJ test.

Data in 3 confirm that the formation of plant branches is also significantly influenced by *seed coating treatment* at 21 DAP, 28 DAP, and 35 DAP (Table 3). FP1 (1.5% CMC + 0.5% Liquid Smoke + 72 grams of $CaCO_3$ + 18 grams of gypsum) produced the highest number of branches (4.75) at 35 DAP, followed by FP6 (4.25) and $FP2_{(4.25).}$ (4.25). Meanwhile, the FP_0 (control) and FP_4 (1.5% CMC + 0.5% Liquid Smoke + 72 grams of $CaCO_3$ + 18 grams of Quicklime) treatments showed the lowest values. Branch development is closely related to seed vigor and initial growth quality. The best results were from the $FP_{1\ treatment.}$ demonstrated that *seed coating* is not only effective in maintaining seed viability during storage and enhancing soybean plant growth, but also in supporting the formation of more optimal plant architecture. This finding is consistent with the reports of Ahmed *et al.* (2018) and Chen *et al.* (2019), which stated that seed treatment can improve plant morphological characteristics and yield potential.

4. Conclusion

Based on the research findings, the following conclusions can be drawn that FP 1 seed coating treatment, consisting of a formulation with 1.5% CMC, 0.5% liquid smoke, 72 grams of CaCO3, and 18 grams of gypsum, produced the best results in the physical growth parameters of soybean plants, including plant height, number of leaves, and number of branches. This finding indicates that the treatment has the potential to enhance soybean seed growth. The study suggests that seed coatings containing CMC, liquid smoke, CaCO3, and gypsum improve soybean seed development. Further research is recommended to evaluate extended storage duration and to more comprehensively assess seed performance and plant growth under field conditions, thereby confirming the effectiveness of the seed coating formulation in real-world agronomic settings.

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