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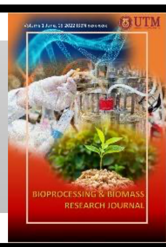

Research Article

The Effect of Sieve Size on Pollen Viability of Several Oil Palm (*Elaeis guineensis* Jacq.) Varieties

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ABSTRACT

High pollen viability plays an essential role in increasing fruit set, achieving optimal yield, and ensuring successful pollination in oil palm (*Elaeis guineensis* Jacq.). Pollen size varies among species and even among varieties within the same species, which may influence its viability level. This study aimed to determine the most suitable sieve size for pollen viability, the best-performing oil palm variety, and the interaction between sieve size and variety on pollen viability. The experiment was arranged in a factorial Randomised Complete Block Design with two factors: sieve size (8, 10, 12, and 14 mesh) and variety (FR 1, Topaz 3, and PPKS 540), each replicated three times. The observed parameters included germination rate, maximum growth potential, growth rate, and pollen tube length, which were analysed using ANOVA in SPSS software. The results showed that sieve size had no significant effect on all pollen viability parameters, whereas the Topaz 3 variety exhibited the highest germination rate, maximum growth potential, and growth speed. No significant interaction was observed between sieve size and variety on pollen viability.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is a dominant plantation crop in Indonesia and serves as a major source of palm oil. In 2023, the total oil palm plantation area in Indonesia reached 15,928,712 ha, producing approximately 48,235,405 tons per year. Riau Province is one of the largest oil palm-producing regions, with fresh fruit bunch (FFB) production recorded at 7,737,099 tons in 2022 and 6,345,345 tons in 2023. In Pelalawan District, FFB production increased significantly from 447,313 tons in 2022 to 1,040,468 tons in 2023 (BPS Riau, 2024).

Oil palm productivity is strongly influenced by genetic factors, particularly varietal differences, which determine key plant characteristics and consequently affect yield. Several commercial varieties are widely cultivated in Indonesia, such as 540 NG, PPKS 540, Yangambi, Langkat, PPKS 239, PPKS 718, Simalungun, AVROS, Sungai Pancur 1 (Dumpy), and SP 540 (Silitonga et al., 2020). In addition to varietal differences, environmental factors such as climate, soil conditions, topography, and cultivation practices play crucial roles in determining productivity. Among these, rainfall and water availability have major impacts on flowering and pollen production (Mangoensoekarjo & Semangun, 2008). Water deficit during the dry season may suppress flower initiation at the leaf axil and increase the differentiation of male flowers compared with female ones. Female flowers that develop under water stress often fail to mature, resulting in a higher proportion of male inflorescences. Conversely, during the rainy season, more female flowers tend to develop (Simanjuntak et al., 2014). Agasy (2024) further reported that although the rainy season promotes female flower formation, pollination failure can occur due to insufficient viable pollen grains.

Pollen viability plays a key role in determining fruit set success and overall yield of oil palm (Hasmeda et al., 2014). High pollen viability ensures higher fertilization rates and fruit production. Variations in pollen size among varieties may influence pollen viability and germination potential (Widiastuti & Palupi, 2008). Pollen grains exhibit diverse morphological characteristics, including differences in size,

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shape, and surface ornamentation, even within the same inflorescence (Cartono & Ibrahim, 2008). According to Agenginardi (2011), the average pollen length and width of oil palm are approximately 39.9 µm and 34.1 µm, respectively. The efficiency of pollen sieving depends on the mesh size used, which should correspond to pollen grain dimensions. A mesh that is too coarse allows impurities to pass through, while one that is too fine may damage or retain the pollen, thereby affecting cleanliness and viability (Mosquera et al., 2021). In other members of the Arecaceae family, such as coconut (*Cocos nucifera*), pollen length ranges between 55–71 µm and width 24–36 µm (Sudha et al., 2022), while in date palm (*Phoenix dactylifera*), pollen length ranges from 17.2 to 26.7 µm (Salamon-Torres et al., 2021). These interspecific variations highlight the importance of determining suitable mesh sizes according to pollen morphology for accurate viability assessment.

Sobari et al. (2019) found that sieving oil palm pollen through 2–12 mesh filters resulted in observable differences in pollen size distribution, with higher fruit set associated with pollen retained on 10–12 mesh filters. Hasmeda et al. (2014) and Widiastuti & Palupi (2008) also reported that sieving through 250 µm or 60 mesh filters produces purer pollen samples for germination tests. This study was conducted using pollen from three oil palm varieties: FR 1 (*First Resources*), Topaz 3, and PPKS 540. Pollen viability was evaluated *in vitro* using the solid Brewbaker and Kwack (BK) medium. According to Kurniawati (2023), the presence of boric acid in BK medium stimulates pollen tube elongation, while nutrients such as calcium nitrate and magnesium sulfate enhance germination. Therefore, this study aimed to determine: (1) the most suitable sieve size for oil palm pollen viability, (2) the best-performing variety in terms of pollen viability, and (3) the combined effect of sieve size and variety on pollen viability.

MATERIALS AND METHOD

Materials and Equipment

The equipment used included a knife, machete, sieves with mesh sizes of 8, 10, 12, and 14, analytical balance, oven, desiccator, freezer, Laminar Air Flow Cabinet (LAFC), refrigerator, autoclave, petri dishes, spatula, microscope, beaker, tweezers, bunsen burner, and glass bottles. The materials used were oil palm pollen from three varieties (FR 1, Topaz 3, and PPKS 540), silica gel, agar, granulated sugar, distilled water, boric acid, calcium nitrate, magnesium sulphate, potassium nitrate, 70% and 96% alcohol, and aluminium foil.

Experimental Design

The experiment was arranged in a factorial Randomised Complete Block Design with two factors. Sieve sizes of 8 to 14 mesh were selected (**Table 1**), as pollen size varies among varieties, making appropriate sieve selection important to avoid impurity passage or pollen loss, and oil palm varieties (FR 1, Topaz 3, and PPKS 540). Each treatment combination was replicated three times, resulting in a total of 36 experimental units.

Table 1 Experimental Design

Var.	Mesh			
	B1	B2	B3	B4
A1	A1B1	A1B2	A1B3	A1B4
A2	A2B1	A2B2	A2B3	A2B4
A3	A3B1	A3B2	A3B3	A3B4

Note: B1 = 8 mesh; B2 = 10 mesh; B3 = 12 mesh; B4 = 14 mesh

Pollen Collection and Sifting

Male flowers are harvested between 09.00 and 12.00. Flowers were dried in an oven at 38 °C for 24 h (Hasemda et al. 2014) and pollen was released by gently tapping them. The pollen was sieved through a sieve measuring 8, 10, 12, and 14 mesh arranged from largest to smallest.

Pollen Storage and Germination Testing

After sieving, the pollen samples were placed in porcelain dishes and stored in a desiccator for two days. The dried pollen was wrapped in aluminum foil, stored in glass vials, and stored in a freezer at -20 °C for one week before testing (Hasmeda et al. 2014).

Pollen viability was tested in vitro using Brewbaker and Kwack (BK) solid media consisting of boric acid, calcium nitrate, magnesium sulphate, potassium nitrate, and 10% sucrose. Approximately 0.01 g of pollen was evenly distributed on the media in a Laminar Air Flow Cabinet (LAF). The Petri dishes were tightly covered with plastic wrap to prevent contamination and incubated at room temperature (Miler & Wonzy, 2021).

Observation Parameters

Pollen viability was evaluated using four parameters (Hasmeda et al., 2014):

1. Germination percentage (%) =
$$\frac{\sum \text{number of germinated pollen grains}}{\sum \text{total pollen grains}} \times 100\%$$

2. Maximum growth potential (%) =
$$\frac{\sum \text{number of normal and abnormal germinated pollen}}{\sum \text{total pollen grains}} \times 100\%$$

3. Germination speed (%) = $\frac{\%KN\ i}{Etmal} + ... + \frac{\%KN\ j}{Etmal}$

   Description:
   KN ij: % of normal germination from observation i to j
   Etmal: Observation time (hours) / 8 hours

4. Pollen tube length (µm), measured under a microscope using ImageJ software.

Data Analysis

Data were analysed using analysis of variance (ANOVA) with SPSS software. Significant differences among treatments were determined using Duncan's Multiple Range Test (DMRT) at the 5% probability level.

RESULTS AND DISCUSSION

Germination Percentage (%)

Based on the ANOVA results, the oil palm varieties showed a significant effect on pollen germination percentage. However, sieve size and the interaction between sieve size and variety had no significant effect. The ANOVA results are shown in **Table 2**.

Table 2 Pollen germination percentage of oil palm (%)

Var.	(Mesh)				Avg. ± SD
	B1	B2	B3	B4	
A1	42.64	42.64	47.00	72.96	51.31±14.58^{ab}
A2	67.00	59.64	72.96	91.00	72.65±13.39 ^{b}
A3	34.32	36.32	38.32	45.32	38.57 ± 4.79^{a}
Avg. ± SD	48.00± 16.98^{a}	46.20± 12.06^{a}	52.76± 18.02^{a}	69.76± 23.01^{a}	(-)

Note: Numbers followed by the same letter are not significantly different according to the Duncan's Multiple Range Test (DMRT) at the 5% significance level.
(A1 = FR 1; A2 = Topaz 3; A3 = PPKS 540; B1 = 8 mesh; B2 = 10 mesh; B3 = 12 mesh; B4 = 14 mesh.) (-) = there is no combination between sieve size and variety)

Table 2 shows that sieve size treatment (8–14 mesh) did not significantly affect germination. Although sieve size was not statistically significant, the 14-mesh sieve produced the highest germination percentage (69.76%), followed by 12 mesh (52.76%), 8 mesh (48.00%), and 10 mesh (46.20%). Among the varieties, Topaz 3 had the highest average germination (72.65%), significantly different from PPKS 540 (38.57%), while FR 1 (51.31%) was not significantly different from either one. These findings agree with Sobari *et al.* (2019), who reported that sieve sizes of 10–12 mesh did not significantly affect pollination success but resulted in fruit set above 80%. Similarly, Jambak (2011) found that 8–10 mesh sieves increased pollen amount but did not improve pollination efficiency. However, those studies primarily evaluated pollination outcomes at the field scale, such as fruit set, without directly assessing pollen viability.

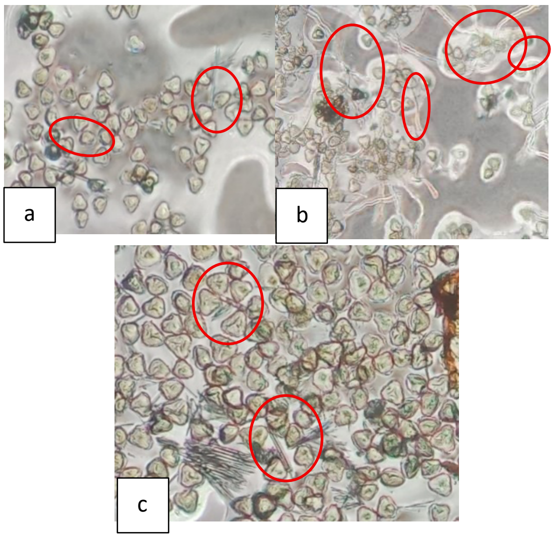

Figure 1 Microscopic pollen (a) FR 1; (b) Topaz 3; (c) PPKS 540

Differences in germination ability among varieties are influenced by internal factors (genetic) and external factors (temperature, humidity, pollen size, flower age) (**Figure 1**). Youmbi et al. (2015) also found that oil palm varieties such as Dura, Pisifera, and Tenera significantly affected pollen germination, with Pisifera showing the highest (≈72%), Tenera (60–65%), and Dura (45–55%). This confirms that genetic factors play a key role in pollen germination capability. No significant interaction between sieve size and variety indicates that sieve size affects pollen germination consistently across varieties. The result aligns with Hasibuan and Sobari (2017), who reported no significant interaction between sieve size (2–12 mesh) and pollination time (morning, noon, evening) on fruit formation in oil palm.

Maximum Growth Potential (%)

ANOVA results showed that variety significantly affected the maximum growth potential (p = 0.000), while sieve size (p = 0.624) and the interaction (p = 0.985) were not significant (**Table 3**).

Table 3 Maximum growth potential of oil palm pollen (%)

Var.	(Mesh)				Avg.± SD
	B1	B2	B3	B4	
A1	52.64	44.64	67.32	101.32	66.98±25.05^{a}
A2	92.00	77.32	88.32	110.00	91.41±13.58^{b}
A3	37.00	38.32	40.96	43.00	38.82± 2.68^{a}
Avg.± SD	60.5± 28.34^{a}	53.4± 20.93^{a}	65.5± 23.73^{a}	84.77 ± 36,44^{a}	(-)

Note: Numbers followed by the same letter are not significantly different according to the Duncan's Multiple Range Test (DMRT) at the 5% significance level.
(A1 = FR 1; A2 = Topaz 3; A3 = PPKS 540; B1 = 8 mesh; B2 = 10 mesh; B3 = 12 mesh; B4 = 14 mesh.) (-) = there is no combination between sieve size and variety)

This suggests that genetic differences among varieties have a stronger effect on pollen growth potential than sieve size. Topaz 3 recorded the highest growth potential (91.41%), significantly higher than FR 1 (66.98%) and PPKS 540 (38.82%). Although sieve size had no significant effect, the highest mean was observed at 14 mesh (84.77%). Genetic factors determine physiological pollen quality and its ability to germinate optimally. Youmbi et al. (2015) and Mosquera et al. (2021) both emphasized that pollen viability and germination rates vary among genotypes even under similar conditions (**Figure 2**).

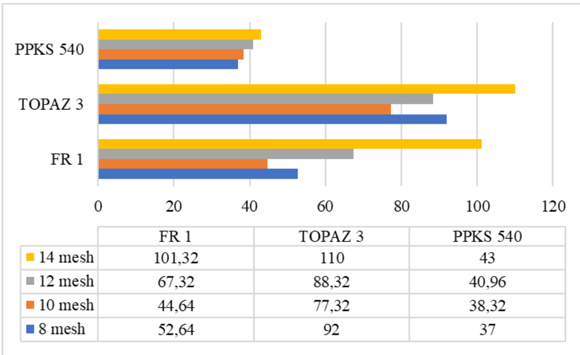

Figure 2 Maximum Growth Potential Graph

According to Soh (2012), pollen from flowers 2–4 days after anthesis shows the highest viability, which decreases after day six. Thus, sieve size mainly functions to separate impurities without influencing pollen physiology. The absence of interaction means variety and sieve size act independently. This agrees with Kakui et al. (2020) and Hasibuan & Sobari (2017), who found that sieve variation did not significantly affect fruit set or pollen growth parameters.

Growth Rate (%)

ANOVA showed that variety had a significant effect on pollen growth rate (p = 0.002). However, sieve size (p = 0.344) and the interaction (p = 0.845) were not significant. Topaz 3 showed the highest growth rate (49.68%), followed by FR 1 (44.08%) and PPKS 540 (27.24%). Among sieves, 14 mesh yielded the highest mean (51.52%), though not significant (**Table 4**). Different growth rates among varieties are attributed to genetic variation, pollen size, and environmental conditions such as temperature and humidity (Lovane et al., 2021).

Table 4 Growth rate of oil palm pollen (%)

Var.	(Mesh)				Avg.± SD
	B1	B2	B3	B4	
A1	34.32	35.76	36.72	71.52	44.08±18.00^{b}
A2	46.56	46.80	50.88	54.48	49.68± 3.77^{b}
A3	25.92	29.04	25.44	28.56	27.24± 1.82^{a}
Avg. ± SD	35.6± 10.38	37.2± 8.97	37.6± 12.75	51.52± 21.64	(-)

Note: Numbers followed by the same letter are not significantly different according to the Duncan's Multiple Range Test (DMRT) at the 5% significance level.
(A1 = FR 1; A2 = Topaz 3; A3 = PPKS 540; B1 = 8 mesh; B2 = 10 mesh; B3 = 12 mesh; B4 = 14 mesh.) (-) = there is no combination between sieve size and variety)

High temperature or low humidity may reduce viability by disrupting metabolic activity. Flower age also affects pollen maturity older flowers produce weaker pollen. These findings confirm that sieve size does not directly influence pollen growth rate (**Figure 3**), but rather improves pollen cleanliness for laboratory testing. This observation is consistent with Sudha et al. (2022), who reported that pollen growth rate is primarily genetically determined.

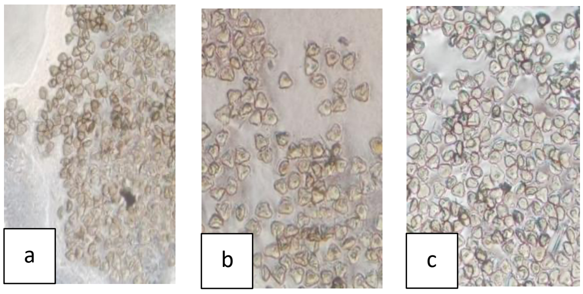

Figure 3. Observation of Topaz 3 Pollen at 14 mesh (a) 8 hours; (b) 16 hours; (c) 24 hours

Pollen Tube Length (µm)

ANOVA showed no significant effect of variety, sieve size, or their interaction on pollen tube length ($p > 0.05$) (**Table 5**). PPKS 540 had the longest mean pollen tube (300.46 µm), followed by Topaz 3 (251.08 µm) and FR 1 (221.30 µm), but differences were not statistically significant.

Table 5 Pollen tube length of oil palm (%)

Var.	(Mesh)				Avg.
	B1	B2	B3	B4	
A1	235.44	229.36	228.04	192.36	221.30± 19.56
A2	291.48	261.04	240.32	211.44	251.07± 33,76
A3	242.80	284.16	251.32	423.56	300.46± 83.98
Avg	256,56± 30.45	258.19± 27.51	239.89 ±11.65	275.78 ±128.33	(-)

Note: Numbers followed by the same letter are not significantly different according to the Duncan's Multiple Range Test (DMRT) at the 5% significance level.
(A1 = FR 1; A2 = Topaz 3; A3 = PPKS 540; B1 = 8 mesh; B2 = 10 mesh; B3 = 12 mesh; B4 = 14 mesh.) (-) = there is no combination between sieve size and variety)

According to Escobar & Dominguez (2018), pollen tube length variation among varieties is usually not significant, as it depends more on physiological pollen condition than on mechanical factors such as sieving. Similarly, Liu et al. (2023) found that environmental factors like temperature, pH, sucrose, and boron concentration have greater influence on pollen tube growth than physical treatments. Microscopic observation (**Figure 4**) showed normal pollen with long, straight tubes indicating healthy cells, while abnormal pollen had short, curved, or broken tubes due to internal or environmental stress.

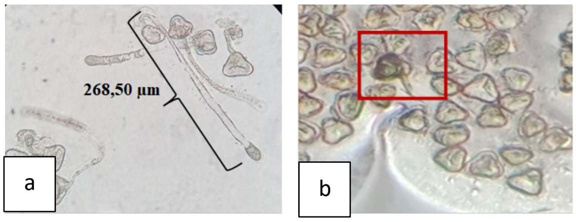

Figure 4. Pollen Tube at 10 mesh (a) Normal (b) Abnormal

CONCLUSION

The results of this study concluded that sieve sizes (8, 10, 12, and 14 mesh) did not have a significant effect on the pollen viability of oil palm (*Elaeis guineensis* Jacq.), as reflected in the parameters of germination rate, maximum growth potential, growth rate, and pollen tube length. However, the oil palm varieties significantly affected pollen viability, with the Topaz 3 variety showing superior performance across most parameters compared to FR 1 and PPKS 540. Additionally, no significant interaction was found between sieve size and variety, indicating that both factors worked independently in influencing pollen viability.

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Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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