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Pod Hardness, Porosity, and Seed Viability Levels of Several Peanut Varieties

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ABSTRACT

The peanut pod shell is composed of cellulose, lignin, and hemicellulose. It has pore channels that can give the seeds direct contact with the environment, resulting in the seeds quickly deteriorating due to temperature fluctuations. This research aims to determine the porosity of the pod shell of several peanut varieties, its relationship with the level of shell hardness, and its effect on seed deterioration that is indicated by seed viability. The research was designed using a randomized block factor design, with the first factor being the type of variety, consisting of Kidang, Hyphoma 3, Landak, Talam 1, Tasia 1, and Takar 1. The second factor was the length of storage, consisting of 1, 2, 3, and 4 months, in quadruplicates, and the hardness of the pods was measured using a digital grain hardness tester meter. Porosity (P) was determined using the volume method. Viability testing includes germination viability (GV), germination rate (GR), and germination rate index (GRI). Pod hardness had a low correlation (*r* = 0.43) with pod thickness and had no effect on shell porosity level; however, pod porosity level had a strong negative correlation (*r* = –0.75) with pod shell thickness. Pod shell porosity, GR, and GRI have an influence on seed germination following the regression equation GR = 145-1.85P – 0.41VG+29.93GRI with a coefficient of determination R^2 = 0.50, meaning that these variables only have a contribution of 50% and other factors influence the other 50%. The shell thickness affects the level of seed germination. The Tasia and Landak varieties with a shell thickness of >0.75 mm produced lower porosity levels and had the least deterioration seed than the other four varieties.

Keywords: germination viability, peanuts, pod hardness, porosity

INTRODUCTION

Seed deterioration is a process that occurs slowly, continuously, cumulatively, and irreversibly that occurs due to internal physiological changes in seeds. Seed regression can be suspected by decreasing the dry weight of sprouts, germination power, vigor index, and respiratory rate (Jawaka 2022). This event is a problem that occurs in the seed storage process. Seed regression is influenced by two factors, namely genetic and environmental. traits (Triani 2021). Genetic factors include oxidative stress responses, DNA repair enzymes, and seed layer composition (Pirreda *et al.* 2023). Meanwhile, environmental factors include temperature, air humidity, seed water content, and gaseous environment (Corbineau 2024; Choudhury and Bordolui 2023).

According to Justice and Bass (2002) and Mustika et al. (2014), seed deterioration is also affected by seed dormancy, shell thickness, and shell structure. Peanut pod shells contain cellulose, lignin, and hemicellulose (Husna and Vasantharuba 2022). Cellulose is a polysaccharide having the formula $(C_6H_{10}O_5)_n$. It consists of linear chains of β (1→4) D-glucose units, ranging from a few hundred to over ten thousand. Lignin is the second most prevalent natural polymer, following cellulose. Lignin is a phenol-based biopolymer with a higher carbon content than oxygen, specifically with a 2:1 ratio, hence its energy content exceeds that of cellulose (Rahayu *et al.* 2019). Hemicellulose is found in vast volumes of complex polysaccharides alongside cellulose. Hemicellulose is a polymer found alongside cellulose that, when degraded, yields hexane and pentose (Bahri 2015). Husna and Vasantharuba (2022) found that peanut pod shells contain 34.183 ± 0.012% cellulose, 18.1 ± 2.423% hemicellulose, and 32.24 ± 0.081% lignin. The amount of cellulose and lignin present affects the toughness of the pod shell. In addition to these three components, peanut pod shells have pore channels that allow water or gas to pass (Zhao *et al.* 2020).

The pores in the pod shell may make the seeds directly tied to the environment. Temperature variations can cause seeds to degrade quickly or shorten their shelf life (Lodong *et al*. 2015). High storage temperatures can increase respiration rates and enzyme activity, causing food stocks to be depleted before seeds germinate, reducing seed vigor and physical quality (Gebeyehu 2020).

Porosity is the proportion of total pore space (void) in units of volume that can be filled with water or air.

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Porosity is measured on a scale of 0 to 1 or as a percentage (0–100%) (Ganat 2020). There are various methods for measuring porosity, including: (a) imbibition method: measuring the volume of liquid absorbed by the material; (b) gas expansion method: using changes in gas volume to calculate porosity; (c) optical method: using observation techniques such as microscopes; and (d) computed tomography: scanning samples with X-rays or neutrons (Anovitz and Cole 2015). Imbibition is the easiest method for measuring the porosity of peanut pod shells. The purpose of this study was to assess the porosity of pod shell in several peanut types using the imbibition method, its relationship to shell hardness, and its effect on seed deterioration as measured by seed viability.

METHODS

The research was carried out from September 2022 to January 2023 in Kendalpayak, Malang. Storage was carried out at open room temperature with the average temperature between September 2022 and December 2022 ranging from 24.4 to 25.4 °C and air humidity of 76.7–84.2%.

Soil was employed as a germination medium, as well as six different peanut varieties: Kidang, Hyphoma 3, Landak, Talam 1, Tasia 1, and Takar 1. Cameras, micrometers, and a computerized grain hardness tester are among the analytical tools used. The study was designed using a Random Design of Factorial Groups, with the first component being the type of variety and the second factor being the storage duration, which was 1, 2, 3, and 4 months long and repeated four times. The factors assessed in this study include pod shell hardness, thickness, and porosity. The pod hardness and pod shell thickness were measured using a digital grain hardness tester and a micrometer, respectively.

The porosity of the shell was calculated using the volume method with the following steps: The initial weight is weighed (*V*o), then the sell was put in water for 2 × 24 hours, drained until there are no droplets, then weighed (*V*t). The porosity volume = (*V*p): *V*t – *V*o, and the porosity was calculated by the formula:

$$P = (Vp/Vt) \times 100\%$$

Viability parameters include germination viability (GV), germination rate (GR), and germination rate index (GRI).

a Germination viability (%):

$$GV = \frac{SP}{ST}\,x100\%$$

where:
GV = Germination viability
SP = The normal number of sprouts produced
ST = Number of seed samples tested

b Germination rate

$$VG = \frac{N1T1 + N2T2 + \cdots + NxTx}{JB}$$

where:
VG = Germination rate
N = Number of seeds germinating at a given unit of time
T = Time lapse between the initial test and the final test at a given interval of an observation
JB = Number of germinated seeds

c. Germination rate index (GRI)

$$GRI = \frac{G1}{D1} + \frac{G2}{D2} + \frac{G3}{D3} + \frac{Gn}{Dn}$$

where:
GRI = Germination rate index
G = Number of seeds germinating on a given day
D = Time corresponding to the germinated seed
n = Number of days at the final calculation

Data Analysis

The data from these parameters were then analyzed using SPSS Statistics 26. The viability parameters and the correlation between porosity and viability are displayed in the form of graphs.

RESULTS AND DISCUSSION

Hardness, Thickness, and Porosity of Pods

The Kidang variety exhibited the highest pod hardness, followed by Hyphoma 3, Landak, Talam 1, Tasia 1, and Takar 1. Meanwhile, the Landak variety had the thickest pods, followed by Tasia 1, Hyphoma 3, Talam 1, Kidang, and Takar 1 (Table 1). The hardness of the pod shell had a slight correlation (r = 0.03) with its thickness. This demonstrates that high shell hardness does not necessarily imply high shell thickness. The influence of shell thickness on pod hardness was relatively minor, with R^2 = 0.19; assuming a 1 mm increase in shell thickness adds just 42 kg of shell hardness. The same principle applies to pod hardness versus porosity. Porosity and pod hardness had a minor correlation (r = 0.29). The influence on porosity is just about 8.8%. However, there is a considerable negative association between porosity level and shell thickness (r = –0.61). This demonstrates that the thicker the shell, the smaller the porosity will be. The influence of pod shell thickness on porosity is up to 38.8%, with an estimate that every 1 mm increase in shell thickness reduces porosity by around 66%. (Figure 1).

The equation P = 82.6 – 14.1 PsT - 0.03 PsH describes the relationship between pod porosity (P), pod shell thickness (PsT), and pod shell hardness (PsH), with a determination coefficient value of R^2 =

Table 1 Pod hardness and thickness

Varieties	Pod hardness (kg)	Pod thickness (mm)
Kidang	6.30±0.48	0.58±0.06
Hyphoma 3	5.36±0.59	0.75±0.13
Landak	5.25±0.62	0.81±0.09
Talam 1	3.61±0.12	0.73±0.12
Tasia 1	3.33±0.18	0.78±0.08
Takar 1	2.27±0.40	0.61±0.07

Remark: Average followed by standard deviation (SD).

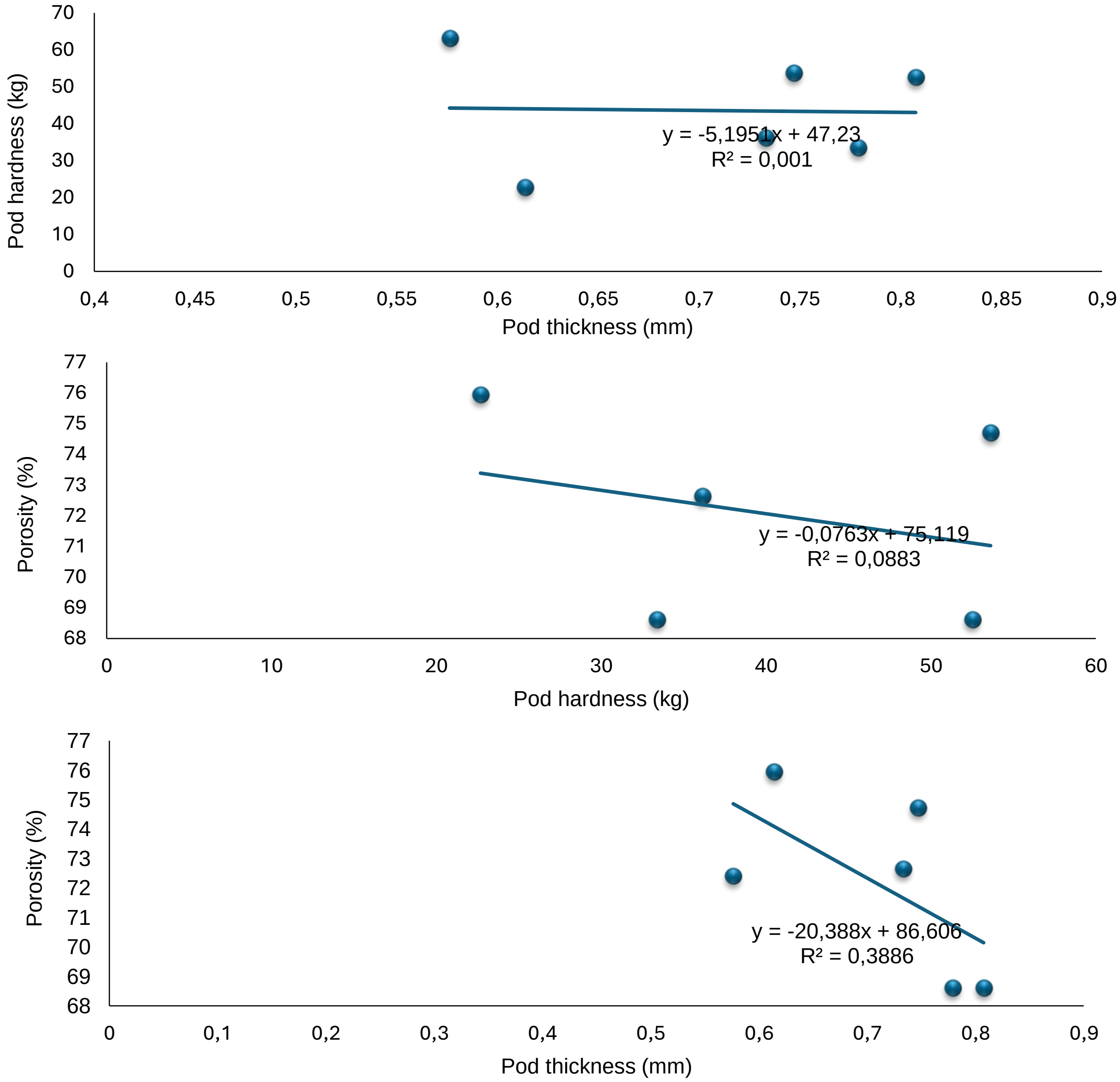

Figure 1 Correlation between hardness, thickness, porosity value of pods. The thickness has more influence on the porosity value than the pod hardness. However, the pod hardness has a weak relationship to the thickness of the pods.

50.8%. This demonstrates that the thickness of the pod shell and hardness only affect 50.8% of the total, with the remainder influenced by other factors, such as variety type.

Porosity of Pod Shell of Each Variety at Storage Time

Some of the examined varieties had porosity ranging from 62% to 77%, which was lower than the porosity of peanut shells from Burkina Faso, which was thought to be up to 98% (Bobet *et al*. 2020). Each variety has a porosity that increases in the second month of storage and then plateaus until the fourth month. After one month of storage, the average porosity was 68.18%, which increased to 71.90% in the second month and stayed constant for the next four months. This is achievable because peanuts are stored at ambient temperature and not refrigerated. The storage temperature ranges between 24 and 25.2 ºC.

Temperature has a significant effect on the rate of lignin depolymerization. At low temperatures, the deterioration process is less efficient, and vice versa. This state is caused by the extreme intricacy and energy of lignin linkages (Dongpo *et al*. 2022). At high temperatures, the hemicellulose, cellulose, and lignin chains begin to degrade into smaller molecules. If this state is maintained, the non-crystalline components of hemicellulose, cellulose, and lignin will experience weaker bond breakage (Kumar et al. 2021). The lignin layer degrades at 20 ºC (Savitri and Purwanto 2019; Kumar *et al*. 2021). The decomposition of lignin may result in voids in the shell layer of peanut pods. The number of particle cavities on the pod shell controls the porosity value (Bobet *et al*. 2020).

Only the varieties Talam 1, Tasia 1, and Takar 1 showed an increase in porosity. Meanwhile, Kidang, Hypoma 3, and Landak have the same porosity after being stored for one month. Based on Table 2, it appears that cultivars with a pod shell thickness greater than 0.75 mm (Table 1) have an average porosity less than 70%.

Porosity and Germination Viability

Porosity in the pod shell causes aeration, which raises the respiration rate of seeds (Andelia *et al*. 2020). The respiration process will deplete the seeds' food reserves, causing a drop in protein, fat, and carbohydrate content (El-Maarouf-Bouteau 2022). This circumstance will affect the fall in germination viability or seed degradation.

The correlation between porosity and germination viability was substantially positive (r = 0.7). The equation GV = 145-1.85P- 0.41VG + 29.93GRI demonstrated the impact of porosity factors, growth rate, and GRI on germination viability. According to the calculation, a one-unit increase in porosity reduces germination viability by 1.85 percent. The equation has a determination coefficient of R^2 = 0.50, indicating that these variables only contribute 50% and the remaining 50% is impacted by other factors.

Correlation between Porosity and Viability in Each Variety

Figure 2 shows that the porosity level has a very weak effect on the VG and GRI variables across all varieties. In terms of germination viability, porosity varies according to variety. Just the Landak and Tasia had a considerable influence on germination, whereas the other four kinds had just a minor effect.

Viability of Varieties in Storage Duration

Germination viability in all varieties decreases with storage time. This is because storage occurs solely at ambient temperature. According to Hasrawati *et al*. (2015), the reason for the decline in germination viability is that the seeds undergo physiological deterioration during storage, resulting in comprehensive changes both physically, physiologically, and biochemically because peanut seeds are only stored at room temperature. High storage temperatures accelerate seed respiration, resulting in higher seed energy loss and a decrease in seed viability during storage. Seeds stored at 70°C and 5°C are more viable for 30 days than those stored at ambient temperature (26°C) (Qulsum 2011).

The Landak and Tasia 1 varieties show higher germination viability than others when stored for up to four months. These two types have the thickest pod shells and the lowest porosity levels among the varieties evaluated. These two cultivars can also maintain good germination viability for up to four months (Figure 3).

Table 2 Porosity level of pod shell of each variety at storage times

Varieties	Porosity value during storage (%)				Average (%)
	1 month	2 months	3 months	4 months	
Kidang	71.20^{b} A	73.34^{ab} A	73.71^{ab} A	71.38^{ab} A	72.40^{ab}
Hypoma 3	75.74^{b} A	71.97^{ab} A	74.68^{b} A	76.46^{b} A	74.70^{b}
Landak	67.26^{ab} A	68.24^{a} A	69.40^{a} A	69.47^{a} A	68.60^{a}
Talam 1	66.34^{a} B	75.41^{ab} A	73.96^{ab} A	74.79^{ab} A	72.63^{ab}
Tasia 1	58.63^{a} B	69.68^{a} A	70.46^{a} A	75.53^{ab} A	68.60^{a}
Takar 1	70.57^{b} B	78.82^{b} A	77.19^{b} A	77.12^{b} A	75.93^{b}
Average (%)	68.93^{b}	73.14^{a}	72.77^{a}	72.78^{a}	

Remarks: The same letter shows the same value based on the 5% LSD test. Capital letters indicate horizontal value comparison, and lowercase letters indicate vertical value comparison.

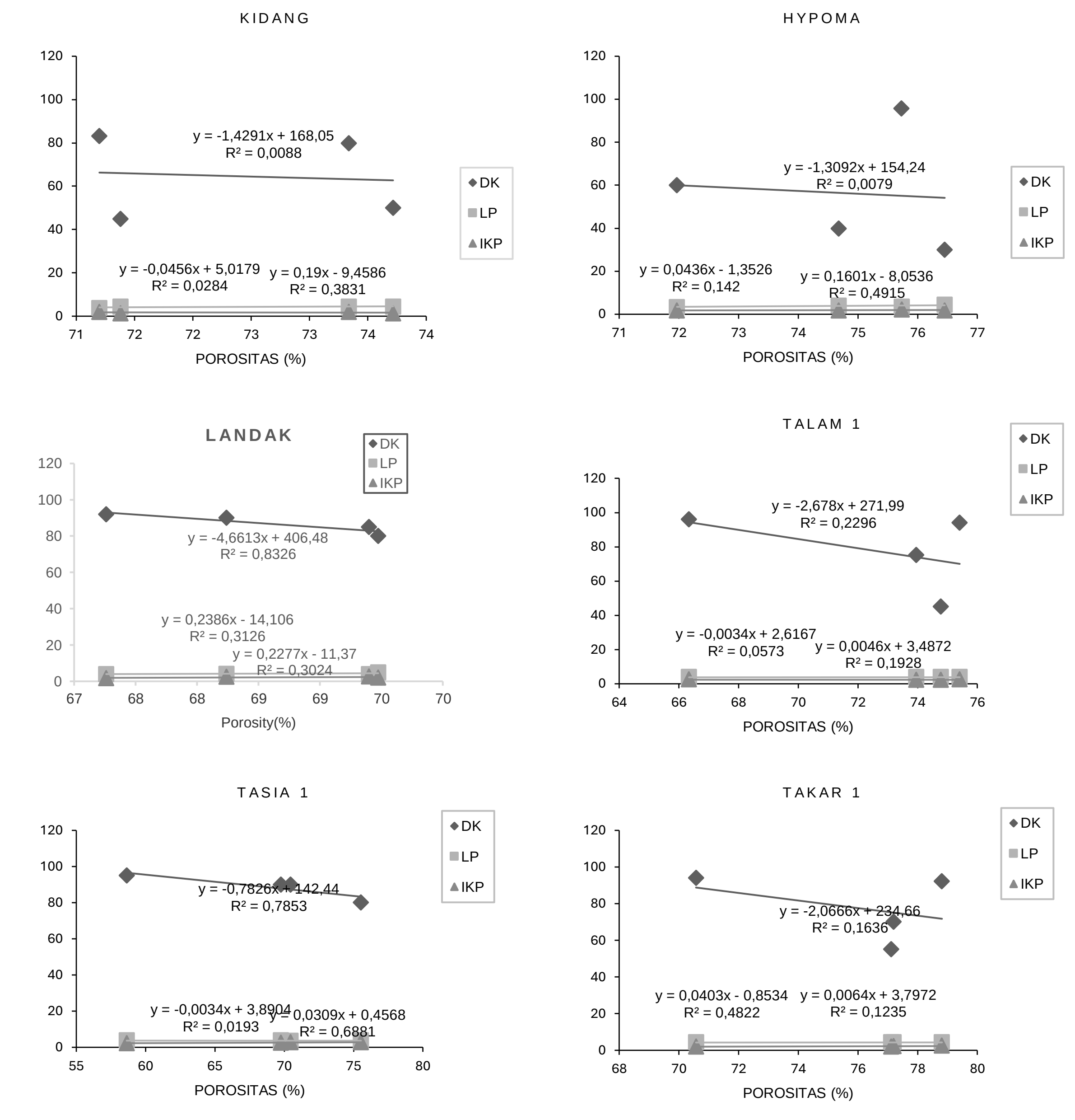

Figure 2 Correlation between porosity, GV (DK), VG (LP) and GRI (IKP) in each variety. GV has a higher correlation with porosity values compared to VG and GRI in all varieties. Among the six varieties, the highest correlation value between GV and porosity value are the Landak and Tasia 1 varieties.

Porosity levels have no effect on GR or GRI; instead, they are determined by genetics. Liu *et al*. (2023) suggested that seed genetic variables influence seed growth rate under optimal environmental circumstances. Figure 4 shows that the Kidang, Landak, and Takar 1 had higher germination rates than the other three. In terms of GRI, the Landak, Talam, and Tasia 1 varieties outperform the other three.

CONCLUSION

Pod hardness has little effect on porosity or germination viability. The thickness of the pod shell influences porosity, which in turn impacts germination viability. Tasia and Landak varieties with shell thicknesses more than 0.75 mm Produce have less porosity and suffered the least seed deterioration as compared to the other four. So, the thickness of the pod shell influences the germination viability of the seeds.

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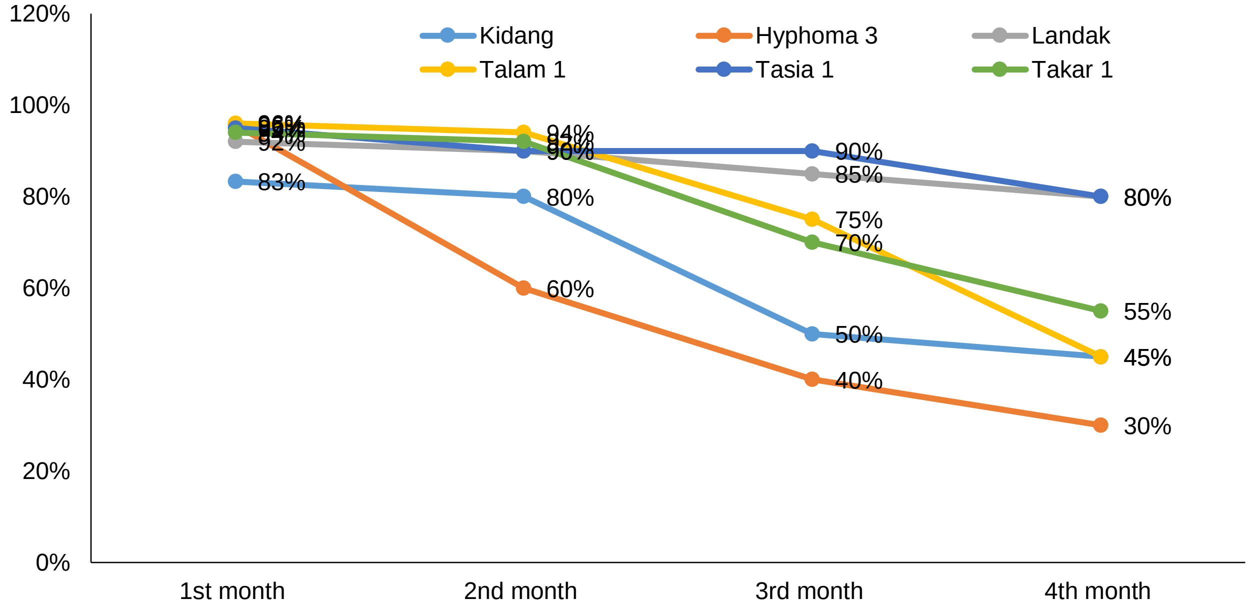

Figure 3 Monthly germination of six varieties.

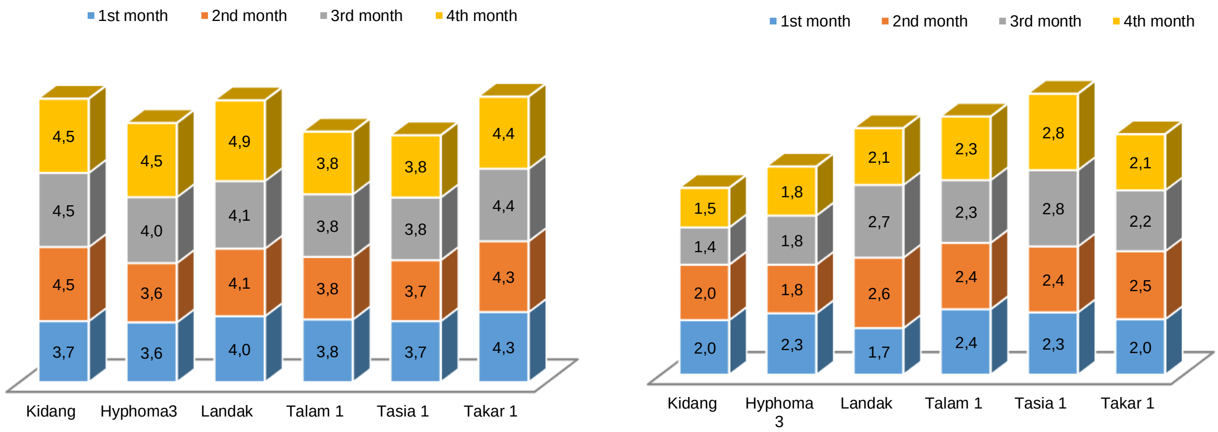

Figure 4 Germination rate (left) and germination rate index (right) of seeds of each variety in the 1st, 2nd, 3rd, and 4th month after planting.

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