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The Effect of Silica Fertilizer Dosage on the Growth and Yield of Three Varieties of Mung Beans (*Vigna radiata*)

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Abstract

Background: Mung beans (*Vigna radiata*) are one of the plants cultivated in Indonesia because they have many benefits, so cultivating mung beans can be a profitable prospect. The use of superior varieties can yield better production results, as can the use of additional fertilizer beyond the basic fertilizer. Silica fertilizer improves harvest quality and strengthens plant stems. This study examined two treatments: the dose of silica fertilizer and three mung bean varieties, aiming to identify the interaction between the dose of silica fertilizer and superior mung bean varieties to achieve better production results. **Method:** This study used a two-factorial completely randomized design (RAL). The first factor was silica dosage (Si_0: 0 ml/l; Si_1: 1 ml/l; Si_2: 2 ml/l; and Si_3: 3 ml/l) and the second factor was mung bean variety (V_1: Vima-1; V_2: Vima-2; and V_3: Kutilang). The combination of silica doses and mung bean varieties in this study resulted in 12 treatment combinations x 3 = 36 experimental units. These were repeated 3 times, yielding 108 experimental units. These combinations were repeated 3 times, yielding 108 experimental units. **Results:** The study revealed that Si_2V_2 (Silica 2 ml/l dan Vima-2) treatment was the most effective in increasing mung bean plant production, with the stem diameter parameter showing the highest value among the treatment combinations, at 9,82 mm. The pod weight parameter per plant also showed that the Si_2V_2 treatment yielded the best results, with a value of 8,80, and the best seed weight parameter per pod was observed in the Si2V2 treatment, with a value of 8,40. **Conclusion:** The applications of silica fertilizer and superior varieties of mung beans significantly affected the observed parameters, and the best results were obtained with the Si_2V_2 treatment (Silica 2 ml/l and Vima-2).

Keywords: Mung Beans; Silica; Varieties

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Introduction

Mung beans (*Vigna radiata*) are a plant belonging to the legume family. Mung beans offer numerous benefits, making them a lucrative prospect when cultivated correctly. Mung beans are rich in nutrients. Vitamins found in mung beans include vitamins E, C, A, K, B6, β-carotene, folate, choline, thiamin, pantothenic acid, and others (Ministry of Health, 2022). Indonesia is unable to produce sufficient yields to meet national needs.

One small step that will significantly increase crop yields is using superior varieties. Many farmers still purchase seeds from traditional markets and are unaware of the benefits and advantages of using superior varieties. This is due to a lack of equitable information dissemination among farmers in Indonesia. A variety is considered stable if it shows no significant changes when observed and planted repeatedly (Sitaresmi et al., 2013). Superior green bean varieties issued by Balitkabi include Vima-1, Vima-2, Vimil-1, Vimil-2, Kutilang, etc.

In addition to using superior varieties, another factor that can help increase mung bean yields is the use of fertilizers other than base fertilizers. An example of this is the use of silica fertilizers. Silica is a highly available component, comprising 28% of the earth's crust

(Apriliyanto, 2020). Most of the silica available to plants is SiO2 in various forms, such as amorphous, crystalline, and poorly crystalline (Tubana et al., 2016). However, tropical regions such as Indonesia have relatively low silica availability due to desilication (Sabatini et al., 2017). Desilication is a process of high leaching and weathering that removes silica from the topsoil, lowering its content in the lower layers (Husnain, 2011).

Applying additional fertilizers in addition to base fertilizers, such as silica, is expected to restore the silica elements affected by the desilication process, thereby fulfilling lost nutrient requirements. Silica fertilizer is a fertilizer that contains the element silica (Si). Silica is sourced from mineral rocks and organic materials (Yuniarti et al., 2017). Silica fertilizer is not considered an essential nutrient. Silica has many advantages, such as improving harvest quality, strengthening plant stems, and increasing resistance to pests and diseases (Fitriani & Haryanti, 2016). This is consistent with research by Yuliatun et al. (2023), which reports that applying silica fertilizer to plants can damage the mouth of larvae. This has a positive impact because it keeps plants from being attacked by pests.

The direct application of silica to plants can protect the plant cuticle, slowing pathogen attack on plant tissue (Vasanthi et al., 2014). Silica can also increase plant growth and resistance to pathogens (Wang et al., 2017). The downside of excessive use of silica fertilizer is that it can reduce nutrient uptake, leading to nutritional imbalances. Applying silica at increasingly higher doses can have negative impacts, as it can reduce nitrogen uptake by plants (Trisnawati et al., 2017).

Silica plays a crucial role in increasing crop yields; therefore, applying silica fertilizer at the correct dosage is expected to impact crop yields significantly (Nurmala et al., 2016). This is consistent with Fadil's (2022) research, which reported positive effects on dry matter, plant height, and 100-seed weight when treated with 100 ppm silica. Research by Musliadi et al. (2025) found that the use of silica fertilizer at a dose of 45 ml/L increased crop yields, and there was an interaction between the 80% field capacity and 45 ml/L silica treatments. Research by Susanto & Raden (2019) found that plants with high silica content can improve plant fertility, and adding silica can increase photosynthetic efficiency. This is because increasing the rate of photosynthesis can also increase photosynthetic yield. Silica can improve soil structure and physical properties by loosening the soil, improving aeration, and enhancing drainage (Hayati et al., 2021).

The proper use of silica fertilizer for mung bean plants also needs to be tested. This study was conducted to determine the appropriate dosage for mung bean varieties to achieve optimal results. This study was conducted by factoring two treatments: silica dosage and three mung bean varieties. This study aimed to determine the appropriate silica dosage for mung bean varieties and to examine the interaction between silica dosage and the three mung bean varieties.

Method

Research Time and Location

This research was conducted on the land of the Surabaya City Food Security and Agriculture Agency (DKPP) in the Balas Klumprik District, Surabaya City, East Java, from March to May 2024.

Research Tools and Materials

The tools used were a watering can, a hand sprayer, scales, labeled calipers, a tape measure, a shovel, etc. The materials used were 20x20 cm polybags, mung bean seeds (Vima-1, Vima-2, and Kutilang varieties), distilled water, liquid silica fertilizer, planting medium, manure, pesticides, urea fertilizer, SP-36 fertilizer, and KCl fertilizer.

Research Methodology

This research was designed using a two-factorial Completely Randomized Design (CRD). The primary factor was the silica (Si) dose, and the secondary factor was the mung bean variety. The primary factor used several concentrations: Si_0: 0 ml/l; Si1: 1 ml/l; Si_2: 2 ml/l; and Si_3: 3 ml/l. The second factor used various varieties of mung beans, namely V1: Vima-1; V1: Vima-2; and V1: Java sparrow.

Si_0V_1 : Silica Fertilizer 0 ml/l (Control) + Vima-1 Variety
Si_0V_2 : Silica Fertilizer 0 ml/l (Control) + Vima-2 Variety
Si_0V_3 : Silica Fertilizer 0 ml/l (Control) + Kutilang Variety
Si_1V_1 : Silica Fertilizer 1 ml/l + Vima-1 Variety
Si_1V_2 : Silica Fertilizer 1 ml/l + Vima-2 Variety
Si_1V_3 : Silica Fertilizer 1 ml/l + Kutilang Variety
Si_2V_1 : Silica Fertilizer 2 ml/l + Vima-1 Variety
Si_2V_2 : Silica Fertilizer 2 ml/l + Vima-2 Variety
Si_2V_3 : Silica Fertilizer 2 ml/l + Kutilang Variety
Si_3V_1 : Silica Fertilizer 3 ml/l + Vima-1 Variety
Si_3V_2 : Silica Fertilizer 3 ml/l + Vima-2 Variety
Si_3V_3 : Silica Fertilizer 3 ml/l + Kutilang Variety

Based on the combination of silica and mung bean dosages above, 12 treatment combinations were obtained. These combinations were replicated three times, resulting in 36 experimental units. After obtaining 36 experimental units, the experiment was repeated three more times, yielding 108 experimental units.

Research Procedure

Planting Media Preparation

This study used a planting medium consisting of a 4:1 mixture of garden soil and cow manure. The mixture was placed in 20x20 cm polybags. The spacing between each polybag was approximately 20x20 cm.

Planting

The mung bean seeds, soaked in warm water for 6 hours, were placed in each perforated polybag, which was 2 cm deep. Two to three mung bean seeds were placed in each hole, then covered with planting medium.

Fertilization

The first fertilization was carried out 1 week before planting, using cow manure at a rate of 1 kg per polybag. Fertilization was applied 1 week after planting at the following rates: urea 25 kg/ha, SP-36 60 kg/ha, and KCl 50 kg/ha (Mustakim, 2016). Each polybag was fertilized with the following amounts: urea 0.1 g/polybag, SP-36 1.2 g/polybag, and KCl 0.2 g/polybag. Silica fertilizer was applied five times, starting at 2, 3, 4, 5, and 6 weeks after planting. Liquid silica fertilizer was dissolved in 1 liter of distilled water at each predetermined concentration (0 ml, 1 ml, 2 ml, and 3 ml) and then sprayed onto the plants.

Maintenance

Maintenance in the study included daily watering and monitoring the surrounding conditions. Weed control was carried out by removing weeds around the study area, and plant pest and disease control (HPT) was carried out according to the plants' needs.

Harvesting

Mung beans are harvested when the pods are ripe, indicated by a color change from green to black.

Data Collection

Data collection was conducted by measuring several plant parameters, such as plant height (cm), number of leaves (leaflets), stem diameter (mm), pod weight, and seed weight per pod.

Data Analysis

The data obtained will be analyzed using Analysis of Variance (ANOVA). If the results are significant, a Least Significant Difference (LSD) test will be performed at the 5% level.

Result

The research results included several observed plant parameters, including plant height, leaf number, stem diameter, pod weight per plant, and seed weight per plant. The following are the results obtained in this study:

Plant Height

The average plant height values for three mung bean varieties combined with silica fertilizer doses from 1 to 5 WAP are presented in Table 1. The average plant height values at 1 WAP showed no significant results, whereas at 2 WAP, they were significant. The highest average yield was observed with the Si_3V_3 treatment at 12.60 cm, while the lowest was observed with the Si_3V_2 treatment at 11.03 cm. The results of the 5% BNT test at 2 WAP showed significant differences between the Si_3V_3 and Si_3V_2 treatments. The highest average yield at 3 WAP was observed with the Si_3V_3 treatment (17.20 cm), while the lowest was observed with the Si_1V_1 treatment (15.41 cm). The 5% BNT test results at 3 WAP showed significant results in the Si_3V_3 and Si_1V_1 treatments. The highest average yield at 4 WAP was observed with the Si_1V_2 treatment, at 27.44 cm, while the lowest was observed with the Si_1V_1 treatment, at 23.21 cm. The 5% BNT test results at 4 WAP showed significant results in the Si_1V_2 and Si_1V_1 treatments. The highest average yield at 5 WAP was observed with the Si_0V_3 treatment, at 32.52 cm, while the lowest was observed with the Si_1V_1 treatment, at 30.29 cm. The 5% BNT test results at 5 WAP were significant for the Si_1V_1 and Si_0V_3 treatments.

Table 1. Average Mung Bean Plant Height

Age (MST)	Treatment	Plant Height (cm)		
		V_1 (Vima-1)	V_2 (Vima-2)	V_3 (Kutilang)
1	Si_0 (0 ml Silica)	0,44	7,76	8,07
	Si_1 (1 ml Silica)	7,70	8,18	8,04
	Si_2 (2 ml Silica)	7,90	8,11	8,14
	Si_3 (3 ml Silica)	7,59	7,79	8,22
	BNT 5%		**tn**	
2	Si_0 (0 ml Silica)	$11{,}22_{a}$	$12{,}52_{de}$	$12{,}31_{de}$
	Si_1 (1 ml Silica)	$11{,}47_{ab}$	$12{,}28_{de}$	$12{,}13_{cde}$
	Si_2 (2 ml Silica)	$11{,}62_{abc}$	$11{,}90_{bcd}$	$12{,}43_{de}$
	Si_3 (3 ml Silica)	$11{,}38_{ab}$	$11{,}03_{a}$	$12{,}60_{e}$
	BNT 5%		**0,65**	
3	Si_0 (0 ml Silica)	$15{,}86_{b}$	$16{,}56_{cd}$	$16{,}71_{de}$
	Si_1 (1 ml Silica)	$15{,}41_{a}$	$16{,}37_{c}$	$16{,}84_{efg}$
	Si_2 (2 ml Silica)	$15{,}74_{b}$	$16{,}99_{fg}$	$16{,}80_{ef}$
	Si_3 (3 ml Silica)	$15{,}46_{a}$	$16{,}98_{fg}$	$17{,}20_{g}$
	BNT 5%		**0,21**	
4	Si_0 (0 ml Silica)	$24{,}82_{c}$	$24{,}94_{c}$	$26{,}14_{e}$
	Si_1 (1 ml Silica)	$23{,}21_{a}$	$27{,}44_{f}$	$26{,}38_{e}$
	Si_2 (2 ml Silica)	$24{,}70_{bc}$	$24{,}29_{b}$	$25{,}63_{d}$
	Si_3 (3 ml Silica)	$24{,}82_{c}$	$25{,}62_{d}$	$27{,}33_{f}$
	BNT 5%		**0,30**	
5	Si_0 (0 ml Silica)	$30{,}70_{ab}$	$31{,}36_{bcd}$	$32{,}52_{fg}$
	Si_1 (1 ml Silica)	$30{,}29_{a}$	$31{,}50_{cde}$	$30{,}91_{abc}$
	Si_2 (2 ml Silica)	$31{,}28_{bcd}$	$32{,}47_{fg}$	$31{,}73_{def}$
	Si_3 (3 ml Silica)	$31{,}68_{de}$	$32{,}17_{efg}$	$32{,}24_{efg}$
	BNT 5%		**0,76**	

Note: Numbers followed by the same letter indicate results that are not significantly different in the 5% BNT test; Weeks After Planting (WAP); tn (not significant)

Leaf Number

The average leaf number of three mung bean varieties combined with silica fertilizer doses from 1 to 5 WAP is presented in Table 2. The average leaf number at 1 and 2 WAP did not differ significantly among treatments. The average leaf number at 3 WAP differed significantly across treatments, with the highest value in the silica treatment (Si2) and the highest in the variety treatment (V_3). The silica treatment at 4 WAP yielded no significant results, whereas the variety treatment did. The average leaf number at 5 WAP across all treatments was significant.

Table 2. Average Leaf Number of Mung Bean Plants

Treatment	Number of Leaves (Sheets)				
	1 MST	**2 MST**	**3 MST**	**4 MST**	**5 MST**
Silica					
Si_0 (0 ml Silica)	1,50	3,03	$4{,}39_a$	5,89	$7{,}92_a$
Si_1 (1 ml Silica)	1,50	3,03	$4{,}36_a$	5,92	$7{,}97_a$
Si_2 (2 ml Silica)	1,50	3,11	$4{,}78_b$	6,28	$8{,}67_b$
Si_3 (3 ml Silica)	1,50	3,06	$4{,}50_a$	6,25	$8{,}64_b$
BNT 5%	**tn**	**tn**	**0,25**	**tn**	**0,44**
Varieties					
V_1 (Vima-1)	2,67	5,44	$7{,}78_a$	$10{,}41_a$	$14{,}11_a$
V_2 (Vima-2)	2,67	5,48	$8{,}04_b$	$10{,}85_b$	$15{,}00_b$
V_3 (Kutilang)	2,67	5,37	$8{,}22_b$	$11{,}19_b$	$15{,}15_b$
BNT 5%	**tn**	**tn**	**0,22**	**0,41**	**0,38**

Description: Numbers followed by the same letter indicate results that are not significantly different in the 5% BNT test; MST (Weeks After Planting); tn (not significant)

Stem Diameter

The average stem diameter values for three mung bean varieties combined with silica fertilizer doses are presented in Table 3.

Table 3. Average Stem Diameter of Mung Bean Plants

Treatment	Stem Diameter (mm)		
	V_1 (Vima-1)	**V_2 (Vima-2)**	**V_3 (Kutilang)**
Si_0 (0 ml Silica)	$7{,}72_a$	$8{,}80_c$	$8{,}54_b$
Si_1 (1 ml Silica)	$7{,}83_a$	$9{,}12_{de}$	$9{,}01_d$
Si_2 (2 ml Silica)	$9{,}28_{ef}$	$9{,}82_j$	$9{,}49_{gh}$
Si_3 (3 ml Silica)	$9{,}50_{hi}$	$9{,}32_{fg}$	$9{,}72_j$
BNT 5%		**0,18**	

Description: Numbers followed by the same letter indicate results that are not significantly different in the 5% BNT test; MST (Weeks After Planting); tn (not significant)

The highest average stem diameter was observed with the Si_2V_2 treatment, at 9.82 mm, while the lowest was observed with the Si_0V_1 treatment, at 7.72 mm. The results of the 5% BNT test for stem diameter showed significant results in both the Si_2V_2 and Si_0V_1 treatments.

Pod Weight Per Plant

The average pod weight values for three mung bean varieties combined with silica fertilizer doses are presented in Table 4. The highest average pod weight was observed with the Si_2V_2 treatment (8.80), while the lowest was observed with the Si_0V_1 treatment (7.23). The results of the 5% BNT test for pod weight showed significant results in both the Si_2V_2 and Si_0V_1 treatments.

Table 4. Average Pod Weight of Mung Bean Plants

Treatment	Pod Weight		
	V_1 (Vima-1)	V_2 (Vima-2)	V_3 (Kutilang)
Si_0 (0 ml Silica)	$7{,}23_a$	$7{,}87_c$	$7{,}77_{bc}$
Si_1 (1 ml Silica)	$7{,}92_{cd}$	$8{,}18_{ef}$	$8{,}26_{ef}$
Si_2 (2 ml Silica)	$8{,}36_f$	$8{,}80_g$	$7{,}82_{bc}$
Si_3 (3 ml Silica)	$7{,}90_{cd}$	$8{,}10_e$	$7{,}63_b$
BNT 5%		**0,21**	

Description: Numbers followed by the same letter indicate results that are not significantly different in the 5% BNT test; MST (Weeks After Planting); tn (not significant)

Seed Weight per Pod

The average seed weight per pod across three mung bean varieties and silica fertilizer doses is presented in Table 5.

Table 5. Average Seed Weight per Pod of Mung Bean Plants

Treatment	Berat Biji Perpolong		
	V_1 (Vima-1)	V_2 (Vima-2)	V_3 (Kutilang)
Si_0 (0 ml Silica)	$7{,}03_a$	$7{,}42_{abcd}$	$7{,}37_{abc}$
Si_1 (1 ml silika)	$7{,}52_{bcd}$	$7{,}78_{cde}$	$7{,}86_{de}$
Si_2 (2 ml silika)	$7{,}96_{ef}$	$8{,}40_f$	$7{,}42_{abcd}$
Si_3 (3 ml silika)	$7{,}50_{bcd}$	$7{,}70_{cde}$	$7{,}23_{ab}$
BNT 5%		**0,44**	

Description: Numbers followed by the same letter indicate results that are not significantly different in the 5% BNT test; MST (Weeks After Planting); tn (not significant)

The highest average seed weight per pod was observed in the Si2V2 treatment, at 8.40, while the lowest was observed in the Si0V1 treatment, at 7.03. The 5% BNT test showed significantly different results in the Si_2V_2 and Si0V1 treatments.

Discussion

Based on the research results, the combination of Si_2V_2 (2 ml silica and Vima-2) treatments yielded the best results. The average pod weight for the Si_2V_2 treatment was the highest at 8.80, indicating that the 2 ml silica dose and the Vima-2 variety can increase mung bean yields. Table 4 shows that the 2 ml silica dose for all mung bean varieties produced the highest yields compared to the other silica doses (0 ml, 1 ml, and 3 ml). The use of silica fertilizer through soil and leaf media can increase crop yields (Taufiq et al., 2020). Silica fertilizer contains components that can support growth and increase plant productivity (Sugiyanta et al., 2018).

The application of 1 ml silica fertilizer in this study yielded suboptimal results, and the application of 3 ml silica fertilizer caused leaf tissue damage, resulting in leaves yellowing easily, drying out, and falling off. Giving too high a dose can affect the plant's leaves, causing them to wilt, burn, or even die (Rahayu, 2020). Leaf damage can inhibit the photosynthesis process in plants. According to Mildaerizanti & Retno (2016), leaf yellowing can damage photosynthetic organs and reduce crop yields by inhibiting the final stages of photosynthesis. Applying silica fertilizer at the correct dose can increase plant resistance to biotic and abiotic stresses. The administration of a 2 ml silica dose in this study yielded optimal results and did not cause plant damage due to excessive silica application.

The combination of silica doses and three superior mung bean varieties showed a significant interaction regarding the number of seeds per pod. The combination treatment of Si_2V_2 (2ml Silica and Vima-2) yielded the highest results, with an average of 8.40. The pod weight parameter per plant, Table 4, shows that the Vima-2 variety has the highest average value among the varieties in the given silica dose treatment. The best mung bean production results were achieved with the Si_2V_2 treatment, reaching 1.68 tons/ha. Apriyani's (2019) research found that Vima-2 yielded low pod weight per plant, with a value of 0.39g, while the highest value was observed in the Kutilang variety, at 0.59g. Also, Vima-2 showed the lowest seed weight per plant, at 0.27g. The use of superior varieties in research can increase production results. Variety selection is important because genetic potential can affect production outcomes. The use of superior purple varieties is a reliable technology for increasing crop yields (Yusuf, 2017).

The results of the study showed a significant interaction between stem diameter parameters and silica doses across various superior mung bean varieties. The best combination was demonstrated by the Si_2V_2 treatment (2 ml of silica and Vima-2), as shown in Table 3, with the highest value of 9.82 mm. The study by Akbar & Mundar (2023) showed the best results at a silica dose of 100 kg/ha, with an average of 1.97 cm. Research by Subiksa (2018) stated that silica fertilizer application can increase stem resilience in rice plants, thereby increasing yields by 117% with an optimum dose of 217 kg S_iO_2 ha-1. Silica fertilizer is applied by spraying it onto all parts of the plant, where it is absorbed. Silica fertilizer plays a crucial role in strengthening plant structure, especially the stem. Silica fertilizers deposit into the vascular and epidermal tissues, thickening and hardening plant cell walls (Zahroin, 2023). Adequate silica application can strengthen plant tissue, resulting in stronger and more robust stems (Nurdin et al., 2018). Research by Dehaghi et al. (2018) also suggests that silica fertilizers reduce transpiration in plants under abiotic stress.

There was no significant interaction in plant height at 1 WAP, as the plants were still growing synchronously, and combining silica and variety treatments significantly improved plant height between 2 and 5 WAP. Silica fertilizer can increase photosynthetic efficiency and optimize nutrient absorption (Fitriyah & Prayogo, 2021). Analysis of variance (ANOVA) on leaf number, silica dosage, and mung bean variety did not reveal any significant interaction; instead, it yielded a single response. The efficiency of photosynthesis during the vegetative phase of a plant can be demonstrated by increased plant height. Increased plant height indicates larger cell size, likely due to greater production of assimilatory compounds (Yuniarti et al., 2017). Silica fertilizer can enhance plant growth and provide nutrient availability for plants in the vegetative phase (Taufiq et al., 2020). Plant responses to various environmental conditions can influence the performance of various plant varieties in their environment (Suhada, 2022). Research by Oktaviani et al. (2020) indicates that if the surrounding environment is not managed correctly, it can reduce production potential, even in superior varieties.

Conclusions

Based on the research results, the use of silica fertilizer and superior mung bean varieties had a significant effect on the observed parameters. The best treatment combination was the Si_2V_2 treatment (2ml Silica and Vima-2), which increased mung bean yields. The silica treatment did not show a significant effect on the number of leaves at 1WAP and 2WAP, and did not show a significant interaction on the plant height parameter at 1WAP. The best production results in this study were achieved with the Si_2V_2 treatment, which yielded 1.68 tons/ha, indicating that a combination of 2 ml/l silica treatment and Vima-2 varieties can be recommended to increase mung bean production yields.

Declaration statement

The authors report no potential conflict of interest.

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