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# POTATO RESPONSE TO LIQUID ORGANIC FERTILIZER AND SILICA IN GROWTH AND PRODUCTION

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## SUMMARY

Potato (*Solanum tuberosum* L.) consumption is in large quantities in Indonesia and worldwide. However, potato production is still quite low in Indonesia. This research aimed to determine the effect of liquid organic fertilizer and silica on potato productivity, with the experiment carried out during 2023 in Sulawesi Selatan, Indonesia. The study used a factorial design of two factors, with the first factor as the liquid organic fertilizer (LOF), consisting of four treatments, i.e., no treatment (control), 150, 200, and 250 mL $L^{-1}$. The second factor was the application of silica fertilizer, comprising four treatments—without treatment (control), 100, 200, and 300 g $m^{-2}$. The results showed liquid organic fertilizer (250 mL $L^{-1}$) and silica fertilizer (300 g $m^{-2}$) produced the maximum plant height, number of leaves, tubers, fresh weight of tubers, and tuber yield at 60.62 cm, 235.36 strands, 8.65, 80.66 g, and 11.29 t $ha^{-1}$, respectively. Additionally, a considerable increase appeared in protein content (2.69%), vitamin C (163.17%), and carbohydrate (14.27%). The optimal combinations of LOF concentrations (150 and 250 mL $L^{-1}$) and silica fertilizer doses (100 and 300 g $m^{-2}$) resulted in the highest phosphorus content (0.15%). The combined application of liquid organic fertilizer and silica demonstrated its effectiveness in enhancing potato crop production.

**Keywords:** Potato (*S. tuberosum* L.), silica fertilizer, liquid organic fertilizer

**Key findings:** In potato (*S. tuberosum* L.) production, a considerable increase was evident with the application of liquid organic and silica fertilizers. The utilization of these inputs showed a highly significant effect compared with the control in the potato.

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## INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the horticultural crops classified as vegetables. Vegetables are essential for the human body, having a pivotal role in growth and health energy. Potatoes are a widely cultivated crop by the farming community commercially because of their various benefits and high economic value (Gonzalez *et al*., 2022). However, the potato production is yet to meet Indonesia's domestic needs due to low yields caused by limited nutrient supply (Yulinarti and Yefriwati, 2021).

Efforts can continue to overcome these problems by providing recommended nutrients and adding macro- and micronutrients to crop plants, which can improve soil fertility and structure, and eventually, increase the crop production. Nutrient provision can occur by using biocam organic fertilizer because it stimulates chlorophyll synthesis in leaves, increases the rate of plant photosynthesis, and optimizes free nitrogen fixation from the atmosphere. The soil, by containing recommended nutrients, can enhance plant growth and vigor, thus making plants healthier and more productive (Moridi *et al*., 2021).

Biocam fertilizer is a liquid organic fertilizer (LOF) with several advantages, viz., reduce the flower and fruit fall, strengthen root and stem tissue, increase production, and a catalyst to lessen usage of basic fertilizers and enhance plant resistance to diseases. Biocam can be applicable to various types of crop plants. In addition to liquid organic fertilizers, nutrient acquisition can also come from using silica fertilizer. Silica fertilizer contains silica nutrients useful in supporting plant growth. Silica can also reduce pest and disease attacks and the threat of temperature, light radiation, wind, and drought (Eso *et al*., 2021).

In soil, sufficient Si also enhances the plant's resistance to nutrient imbalances, such as, excess N, deficiency, and excess of P, and poisoning of Na, Fe, Mn, and Al. Hence, one can conclude the application of LOF and silica fertilizers is highly beneficial in increasing the growth and production of potatoes. However, information about the combination of LOF and silica fertilizers as providers of nutrients for potato plant growth and production is still lacking. Therefore, the main aim of this study was to determine the role of LOF and silica fertilizers on potato growth and production.

## MATERIALS AND METHODS

### Experimental site and procedure

The timely research on *S. tuberosum* L. commenced in 2023 in South Sulawesi, Indonesia. The study used a two-factor factorial design, with the first factor as the LOF fertilizer application with four treatments, i.e., without treatment (b0 = control), 150 mL $L^{-1}$ (b1), 200 mL $L^{-1}$ (b2), and 250 mL $L^{-1}$ (b3). The second factor was applying silica fertilizer comprising four treatments—without treatment (S0 = control), 100 g $m^{-2}$ (S1), 200 g $m^{-2}$ (S2), and 300 g $m^{-2}$ (S3). In total, 16 treatment combinations ensued, with three repetitions, totaling 48 experimental units.

### Tillage and fertilization

The research area for use incurred initial clearing of dirt and weeds. Subsequently, pre-planting with herbicide spraying used Golma 240 EC to suppress weed growth in the planting area. Following this, the beds' development had dimensions of 1.2 m × 4 m, a height of 30 cm, a distance of 30 cm between beds, and a distance of 50 cm between groups. Fertilization transpired seven days before planting using silica fertilizer with various doses, according to the treatments—no treatment (S0), 100 g $m^{-2}$ (S1), 200 g $m^{-2}$ (S2), and 300 g $m^{-2}$ (S3). The subsequent stage involves the installation of plastic mulch, which then sustained hollowing out based on the predetermined planting distance, and the placement of treatment pegs on each bed.

### Planting

Potato tuber planting of the granola proceeded with a prescribed planting configuration of 60 cm × 40 cm, situating the individual potato tubers in planting holes at a depth of 10 cm, yielding one tuber per hole. This configuration establishes 21 populations within each experimental subplot. The planting holes, augmented with bulbs, subsequently received loose-soil backfilling. Before the planting process, each plot underwent labeling corresponding to its designated treatment, streamlining both the planting procedure and subsequent field observations.

**Liquid organic fertilizer application**

The application of LOF (Biocam) occurred three times, specifically at 15 days after planting (DAP), 30 DAP, and 45 DAP. The treatments involved varying concentrations, denoted as without treatment (b0 = control), 150 mL $L^{-1}$ (b1), 200 mL $L^{-1}$ (b2), and 250 mL $L^{-1}$ (b3), administered three times at 15, 30, and 45 DAP. The application employed spraying the potato plants using a hand sprayer, with an application volume set at 20 mL.

**Data recorded and analysis**

The data recording on various growth, tuber yield, and biochemical parameters included plant height (cm), number of leaves (strands), number of tubers, fresh tuber weight (g), tuber yield (t $ha^{-1}$), protein (%), vitamin C (%), carbohydrate (%), and phosphorus (%). The subsequent data analysis used various statistical methods, including analysis of variance (ANOVA) using Microsoft Excel 2021. In the presence of significant differences among the treatments, the Tukey test ($p \leq 0.05$) continued to discern the mean differences among the various treatments.

**RESULTS AND DISCUSSION**

Potato growth and production gained significant influences from the biocam concentration and silica dosage, as shown in Table 1. The biocam treatment had an insignificant effect for two parameters: plant height and fresh tuber weight; a substantial effect for one parameter: number of tubers; and a highly notable effect for two parameters: number of leaves and tuber yield. Meanwhile, the silica treatments had an insignificant effect on three parameters: number of leaves, number of tubers, and tuber yield; a noteworthy effect on one parameter: fresh tuber weight; and a vastly significant effect on one parameter: plant height.

According to the analysis of variance, silica doses individually altered significantly potato plant height (Table 2). The highest average plant height showed an association with the silica treatment (300 g $m^{-2}$), measuring an average plant height of 60.62 cm. The said promising treatment appeared remarkably different from the control treatment (S0), however, nonsignificantly different from the silica doses (200 and 100 g $m^{-2}$). Conversely, the lowest average plant height was visible in the control treatment (S0), with an average plant height of 51.28 cm. The results also indicated nonsignificant interaction effects between the LOF concentrations and silica doses concerning the plant height in potatoes. Differences in silica doses affect the growth and production of potato plants, and the optimum dose exhibited the best yield compared with other treatments. This demonstrates the application of silica fertilizer has the potential to enhance growth and facilitate nutrient availability to plants.

Silica fertilizer application to potato plants accelerates the synthesis of amino acids and proteins, thereby promoting the overall plant growth. These findings align with research that suggested silica can inhibit oxidative compounds causing stress, leading to increased antioxidant enzymes and optimal plant growth and production (Sapre and Vakharia, 2016). Zeolite application results in reduced Na+ ion absorption, increased soil CEC, and enhanced fertilization efficiency, ultimately benefiting plant growth and increasing plant height (Rahayu *et al*., 2019). Additionally, Sabatini *et al*. (2017) reported silicon treatment contributes to a rise in the plant height.

The LOF concentrations significantly affected the number of leaves in potato plants (Table 2). An association of the topmost average number of leaves (235.36 strands) was with the LOF treatment 250 mL $L^{-1}$. The said treatment notably differed from the control treatment; however, it did not vary

**Table 1.** Effect of biocam concentrations and silica doses on various parameters.

| Parameter | Effect | | KK (%) |
|---|---|---|---|
| | Biocam | Silica | |
| Plant height (cm) | NS | ** | 9.82 |
| Number of leaves (strands) | ** | NS | 13.56 |
| Number of tubers | * | NS | 20.33 |
| Fresh tuber weight (g) | NS | * | 24.46 |
| Tuber yield (t $ha^{-1}$) | ** | NS | 17.68 |

Remarks: **: very real effect, *: have a real impact, NS: Nonsignificant in the BNJ test of variance (ANOVA) α 0.05. KK=Diversity Coefficient.

**Table 2.** Effect of biocam concentrations and silica doses on plant height and number of leaves (strands) in potato.

| Treatments | Plant height (cm) | Number of leaves (strands) |
|---|---|---|
| Biocam | | |
| Control | $55.56_{p}$ | $190.18^{b}$ |
| 150 mL $L^{-1}$ | $54.78_{p}$ | $211.10^{ab}$ |
| 200 mL $L^{-1}$ | $57.23_{p}$ | $212.86^{a}$ |
| 250 mL $L^{-1}$ | $60.90_{p}$ | $235.36^{a}$ |
| Silica | | |
| Control | $51.28_{q}$ | $219.77^{a}$ |
| 100 g $m^{-2}$ | $56.19_{pq}$ | $222.66^{a}$ |
| 200 g $m^{-2}$ | $60.38_{p}$ | $225.93^{a}$ |
| 300 g $m^{-2}$ | $60.62_{p}$ | $222.79^{a}$ |

Remarks: The numbers followed by the same letters (a, b) and (p, q) were not significantly different in the BNJ follow-up test α 0.05.

significantly from the LOF concentrations of 200 and 150 mL $L^{-1}$. Conversely, the lowest average number of leaves resulted in the control treatment, with an average of 190.18 strands. The results also revealed no interaction effects between the LOF concentrations and silica doses concerning the average number of leaves in potatoes. The nitrogen (N) nutrients found in LOF fertilizer served to enhance the leaf growth and nourished the leaves, with a positive correlation observed between the concentration of LOF and the potato growth and leaf number. Dhani *et al*. (2013) reported the formation of leaves in plants displayed prominent effects from the nutrients' availability in the growing media.

In alignment with the study conducted by Kwon *et al*. (2019), the study established that leaf production in plants bore significant influences from nutrient absorption in the growing media. The application of LOF fertilizer proves beneficial in enhancing available nutrients and facilitating photosynthesis, thereby contributing to improved crop yields. Yusdian *et al*. (2022) emphasized the absolute necessity of adequate and balanced nutrients for optimal plant growth and development. Adequate plant nutrition supports well-executed physiological processes, and biocam fertilizers, containing both macro- and micronutrients, proved indispensable for crop plants.

The LOF concentrations considerably influenced the number of tubers in potatoes (Table 3). The most number of tubers correlated with the LOF concentration (250 mL $L^{-1}$), with an average of 8.65. The said treatment nonsignificantly differed from the LOF treatment (200 mL $L^{-1}$). However, it appeared significantly different from the LOF concentration of 150 mL $L^{-1}$ and the control treatment. Conversely, the lowest average number of tubers was evident in the control (6.73). The interaction effects between the LOF concentrations and silica doses concerning the average number of tubers were nonsignificant. Kantikowati *et al*. (2019) observed applying LOF influences the produced number of tubers in potato (*S. tuberosum* L.) due to its composition containing humic acid and fulvic acid.

The observed data on fresh weight tubers are available in Table 3. Analysis of variance revealed no interaction between the LOF concentration treatment and silica dose concerning the average fresh weight of tubers. The silica doses significantly influenced the fresh tuber weight in potatoes (Table 3). The supreme average fresh tuber weight (80.66 g) resulted from the silica dose of 300 g $m^{-2}$. The said treatment appeared significantly different from the control treatment and the silica dose of 100 g $m^{-2}$; however, it nonsignificantly differed from the silica dose of 200 g $m^{-2}$. The lowest average fresh tuber weight manifested in the control treatment (59.00 g).

Silica fertilizer exerts multiple positive influences on plant growth and yield, notably impacting the tuber weight. Silica fertilizer comprises various components, with potassium being one of them. Potassium plays a crucial role in the physiological and metabolic processes of crop plants. Hou *et al*. (2019) identified potassium as essential in plant metabolism, particularly in processes like photosynthesis, where it contributes to photosynthates production stored in plant parts, including tubers. Potassium also serves as an enzyme activator, facilitating the synthesis and breakdown of carbohydrates. Moreover, potassium affects the transport of phosphorus within plant parts (Cui and Tcherkez, 2021).

For tuber yield, the LOF concentrations enunciated significant differences (Table 3). The maximum average tuber yield emerged with the LOF concentration of 250 mL $L^{-1}$, averaging a value of 11.29 t $ha^{-1}$. The said LOF treatment markedly differed from other LOF concentrations (200 mL $L^{-1}$), control, and other treatments. However, the minimum average tuber yield resulted in the control treatment (8.39 t $ha^{-1}$). The interaction of LOF concentrations and silica doses concerning the average tuber yield revealed nonsignificant differences. LOF fertilizer contains an adequate and well-balanced nutrient composition, contributing to potato tubers' formation.

Sutrisna and Surdianto (2014) reported organic and inorganic fertilizers result in prolific potato tuber production due to their sufficiency in essential nutrients. These observations underscored the importance of a balanced and sufficient nutrient supply in influencing the metabolic processes of plant growth and enhancing overall yield. Furthermore, nitrogen, a component of LOF, stimulates cell elongation, increases tuber count, and boosts tuber yield and protein content. The absorption of more nutrients by crop plants correlates positively with the size and weight of potato tubers (Supriyono, 2012).

**Table 3.** Effect of biocam concentrations and silica doses on the plant height, number of leaves, number of tubers, fresh tuber weight, and tuber yield in potato.

| Treatments | Number of tubers | Fresh tuber weight (g) | Tuber yield (t $ha^{-1}$) |
|---|---|---|---|
| Biocam | | | |
| Control | 6.73a | 60.76a | 8.39b |
| 150 mL $L^{-1}$ | 7.53ab | 70.92a | 9.29b |
| 200 mL $L^{-1}$ | 7.60a | 65.43a | 9.32b |
| 250 mL $L^{-1}$ | 8.65a | 72.35a | 11.29a |
| Silica | | | |
| Control | 6.60q | 59.00q | 8.77q |
| 100 g $m^{-2}$ | 7.98q | 61.14q | 9.89q |
| 200 g $m^{-2}$ | 7.67q | 68.67p | 9.85q |
| 300 g $m^{-2}$ | 8.27q | 80.66p | 9.79q |

Remarks: The numbers followed by the same letters (a, b) and (p, q) were not significantly different in the BNJ follow-up test α 0.05.

The highest average protein content (2.69%) was evident with the interaction of LOF concentration (250 mL $L^{-1}$) and silica dose (300 g $m^{-2}$) (Table 4). Conversely, the lowest average protein content (2.06%) was noticeable in the control treatment. Observational data on vitamin C content revealed that the topmost vitamin C (163.17%) appeared with the interaction of LOF concentration (250 mL $L^{-1}$) and silica dose (300 g $m^{-2}$). However, the least average vitamin C content resulted in the control treatment (108.91%). The increase in LOF concentration, coupled with elevated silica doses, correlates with a higher protein content. This phenomenon is due particularly to the heightened presence of nitrogen elements compared with other treatments, leading to raised protein content.

Wijaya *et al*. (2015) reported nitrogen serves as a primary constituent element of proteins, alongside elements C, H, O, and S. Under low nitrogen conditions, protein formation diminishes, and conversely, an increase in nitrogen content in plant tissues results in elevated protein levels. Similarly, the rise in LOF concentration, coupled with high silica doses, interlinked with an increase in vitamin C content. This purportedly refers to the influence of heightened protein elements versus other treatments. Vitamin C's intricate linkage to proteins serves as precursor materials synthesized into vitamin C. Wijaya's *et al*. (2015) findings revealed proteins undergo partial synthesis into vitamin C in fruits.

The combined application of LOF concentration (250 mL $L^{-1}$) and silica dose (300 g $m^{-2}$) exhibited the highest average carbohydrate content (14.27%) (Table 4). In contrast, the control treatment gave the lowest average carbohydrate content (11.17%). The maximum average phosphorus content was evident in combined treatments of LOF (150 mL $L^{-1}$) and silica dose (100 g $m^{-2}$), LOF (150 mL $L^{-1}$) and silica (300 g $m^{-2}$), and LOF (250 mL $L^{-1}$) and silica dose (300 g $m^{-2}$). All these treatments resulted in an average phosphorus content of 0.15%. Conversely, the lowest average phosphorus content occurred in the control groups, with an average of 0.12%.

The carbohydrate content, particularly starch, represents a key characteristic influencing the edible quality of potatoes. In this study, the maximum concentration of LOF and silica dose led to an increase in starch content within the potato tubers. Starch levels in potatoes bore influences from chlorophyll-a content in leaves and photosynthetic capacity (Wadas, 2023). Trawczynski (2016) reported the starch content primarily attained effects from cultivation practices, with nitrate levels determined by weather conditions during the potato growth period.

The variations in LOF concentrations and silica doses yielded the most significant impact on phosphorus content, averaging 0.15% (Table 4). The combination of LOF and silica fertilizer comprises several ingredients, including potassium, aligning with the findings of Hou *et al*. (2019). Potassium plays a critical role in plant physiological and metabolic

**Table 4.** Effect of biocam concentrations and silica doses on the protein (%), vitamin C (%), carbohydrate (%) and phosphorus content (%) in potato.

| Treatments | Protein (%) | Vitamin C (%) | Carbohydrate | Phosphorus |
|---|---|---|---|---|
| B0S0 | 2.06 | 108.91 | 11.17 | 0.12 |
| B0S1 | 2.09 | 136.37 | 11.99 | 0.13 |
| B0S3 | 2.31 | 162.49 | 12.77 | 0.14 |
| B1S0 | 2.18 | 135.39 | 13.80 | 0.12 |
| B1S1 | 2.32 | 137.14 | 12.47 | 0.15 |
| B1S3 | 2.21 | 109.33 | 13.51 | 0.15 |
| B3S0 | 2.17 | 135.54 | 12.74 | 0.12 |
| B3S1 | 2.61 | 135.72 | 11.94 | 0.14 |
| B3S3 | 2.69 | 163.17 | 14.27 | 0.15 |

Source: Feed Chemistry Laboratory, Department of Nutrition and Animal Feed, Faculty of Animal Husbandry, Hasanuddin University, Makassar.

processes, influencing metabolism, photosynthesis, and storage of synthesized carbohydrates in potato tubers. Additionally, potassium activates enzymes involved in carbohydrate synthesis and breakdown and affects the phosphorus transport in crop plants (Cui and Tcherkez, 2021; Haq *et al*., 2021; Yusubakhmedov *et al*., 2024).

## CONCLUSIONS

The combined application of LOF (250 mL $L^{-1}$) and silica (300 g $m^{-2}$) resulted in the best performance and the highest values for various plant heights (cm), number of leaves, number of tubers, fresh tuber weight (g), tuber yield (t $ha^{-1}$), protein (%), vitamin C (%), and carbohydrate content (%). Similarly, LOF concentrations (150 and 250 mL $L^{-1}$), along with a silica fertilizer (100 and 300 g $m^{-2}$), revealed the maximum phosphorus content (%).

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