The effect of silica source concentration to improve growth of *Lactuca sativa* L. on floating hydroponic system

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Abstract. The efficiency of nutrient absorption in lettuce cultivation with a floating raft hydroponic system can increase productivity and reduce hydroponic nutrients operational costs. This study aims to study the concentration of silica elements from silica sources made from rice husks and synthetic silica on lettuce plants' growth. This research was carried out in April 2019-May 2019 at the greenhouse of the Faculty of Agriculture, Padjadjaran University, Jatinangor-Sumedang, Indonesia. The research method used was a complete randomized design consisting of five treatments, namely, without silica, 6 ppm synthetic silica, 3 ppm rice husk silica, 6 ppm rice husk silica, and 9 ppm rice husk silica. Each treatment was repeated five times to obtain 25 units of the experiment. Growth parameters observed were plant height, number of leaves, leaf area, fresh weight, and shelf life at room temperature. The observational data were then analysed by analysis of variance at 5% level and Duncan test at 5% level. The results showed that the concentration of silica sources affect plant height and number of leaves. The application of 6 ppm rice husk silica concentration increased the fresh weight of plants 26% higher than without the application of silica.

1. Introduction

The element silica (Si) role in agriculture has been considered necessary, especially in several plants. Elemental Si can increase plant nutrient uptake and suppress biotic and abiotic stress [1,2]. The availability of the Si element in the hydroponic system is obtained from the water used and the planting medium. With a note that the water and the planting medium used to dissolve nutrients contain the element Si. The Si content in water and the growing media used is low or even absent. Then it is necessary to add Si elements to the hydroponic nutrition used [3].

The floating hydroponics systems (FHS) has an advantage as a simple hydroponics system. The FHS also has a weakness in providing oxygen for the plant. Low dissolved oxygen (DO) in the nutrient solutions is abiotic stress that will inhibit plant growth [4]. The application of the Si element on lettuce cultivation hydropically can reduce the impact of abiotic stress. Lettuce is a type of plant that responds to Si's addition to hydroponic nutrition, so application Si has a benefit to reduce the impact of plant stress and improve lettuce growth [5]. Rice husks are a Si source, derived from organic materials that are readily available in large quantities [6,7]. The use of rice husks as a source of silica can increase the added value of the husks. The diversification of the use of waste produced by rice mills can reduce rice husk waste accumulation. In some areas, rice husks are used as rice husk charcoal for plant growth media and coops on broiler farms. Previous research shows that the application addition of Si element in the nutrients solution increases iceberg lettuce taller and breadth.
compared to without Si element addition [2]. This study aims to determine the effect of rice husk silica extract and types of silica fertilizers on hydroponic cultivated lettuce's growth.

2. Materials and methods

2.1. Time and place
This research was conducted from April 2019 to May 2019 in the greenhouse of the Faculty of Agriculture-Universitas Padjadjaran, Sumedang Regency, West Java Province (± 757 m above sea level).

2.2. Material and tools
The equipment and materials used are nutrient box (30 cm x 20 cm x 10 cm), aerator, PE pipe, electrical conductivity meter (EC meter), pH meter, thermo-hygrometer, hand sprayer, analytic scale, oven, lettuce seed cultivar Kriebo, Rockwool, net pot, AB mix nutrient, rice husk, and rice husk charcoal.

2.3. Research methods
This research used a completely randomized design consisting of five treatments (A = control without silica; B = synthetic silica control 6 ppm; C = rice husk silica 3 ppm; D = rice husk silica 6 ppm; E = rice husk silica 9 ppm). Each treatment was repeated five times. Growth parameters observed and measured were plant-height 35 days after transplanting, number of leaves, leaf area, fresh weight, and shelf life at room temperature.

2.4. Research implementation
The research procedure is divided into two stages, namely the preparation stage and the research implementation stage. The preparation stage includes rice husk silica extract production, making nutrition boxes, seeding seeds, making hydroponics nutrients or AB mix, and cleaning the greenhouse.

The implementation stage (figure 1) is transplanting maintenance, and applying Si fertilizer, controlling plant pests, husk silica extract, and harvesting.

![Figure 1](image-url)

**Figure 1.** The implementation stage of research (a) transplanting, (b) maintenance application Si fertilizer, (c) controlling, and (d) harvesting
2.4.1. Transplanting. This process is a transplant lettuce plant from a seedling tray (after 12 days) to a net-pot on hydroponics installation (figure 1a).

2.4.2. Maintenance & Si application. The maintenance process includes maintaining the hydroponic system and controlling the nutrient solution electrical conductivity (EC) every day. Controlling EC value is an important activity to ensure that the plant absorbs the nutrients at optimum conditions. The first week's EC values used 1.4 mS cm\(^{-1}\), second week 1.8 mS cm\(^{-1}\), third week 2.0 mS cm\(^{-1}\), and the fourth week until harvest used EC 2.4 mS cm\(^{-1}\).

The application of Si fertilizer was given three times in the second week until the fourth week. The Si application methods is given by spraying to the plant leaves (28 ml per plant).

2.4.3. Controlling plant pests. Controlling the plant pests is do every day until the lettuce plant harvests. This process is to ensure the pests is do not attack the plant widely.

2.4.4. Harvest. Harvesting is done when the plant age 35 days after transplanting. The lettuce plant is harvested carefully by pick up the plant from the net pot.

2.5. Data analysis

The observed data were then analysed using variance analysis at the 5% level and Duncan's multiple range test at the 5% level.

3. Results and discussion

The results of the analysis of variance (table 1) show that the application of silica (Si) fertilizer affects the parameters of plant height and number of leaves. The type of silica fertilizer does not influence other parameters, namely leaf area, fresh weight, and shelf life at room temperature.

Table 1. Plant height, number of leaves, leaf area, fresh weight, and shelf life of *Lactuca sativa* L. on with application of silica on floating hydroponic system.

| Treatment                  | Plant Height (cm) (35 DAT) | Number of leaves (leaf) (35 DAT) | Leaf area (cm\(^{2}\)) | Fresh Weight (g) | Shelf life (day) |
|----------------------------|---------------------------|---------------------------------|------------------------|------------------|------------------|
| A (control without silica) | 32.55 a                   | 9.05 a                          | 1187.15 a              | 60.85 a          | 4.0 a            |
| B (synthetic silica control 6 ppm) | 36.29 b                 | 9.50 a                          | 1137.76 a              | 62.90 a          | 4.4 a            |
| C (rice husk silica 3 ppm)  | 37.44 b                   | 9.85 a                          | 1540.27 a              | 63.90 a          | 3.8 a            |
| D (rice husk silica 6 ppm)  | 38.39 b                   | 11.05 b                         | 1506.07 a              | 76.65 a          | 3.8 a            |
| E (rice husk silica 9 ppm)  | 36.03 b                   | 10.95 b                         | 1493.89 a              | 68.50 a          | 4.0 a            |
| CV (%)                     | 6.70                      | 6.06                            | 16.41                  | 19.90            | 14.58            |

Remarks: CV = Coefficient of variance; ns = non-significant, *= significant

3.1. Plant height

Based on table 1, the height of the plants treated with silica was significantly different from those without silica application. The results of this study confirmed previous studies that stated that the element Si could increase the height of lettuce [2,8,9]. The role of the element Si on specific plant growth for certain plant types and certain plant organs that are influenced by the element Si [10]. The types of synthetic silica fertilizers 6 ppm and silica fertilizers from the extraction of rice husks (3 ppm, 6 ppm and 9 ppm) gave the same results for adding plant height. The Si affects the rigidity of cell wall and strength, improve nutrient uptakes and photosynthesis. Plants that are fulfilled by their nutrient needs show higher plant growth than plants with limited nutritional needs [11].
3.2. Number of leaves
The type of Si fertilizer effects on the number of leaves (table 1). The Si fertilizer derived from the extraction of rice husks at a concentration of 6 ppm and 9 ppm, which is significantly different from the treatment without Si element application, 6 ppm synthetic silica fertilizer, and 3 ppm rice husk silica extract. The increase in the number of leaves is directly proportional to the plant's height.

The Si element in lettuce helps increase nutrient uptake in plants, especially NO₃, N, P, and Ca. The Si element effect on the leaf number parameter in this study was different from previous studies, which stated that the addition of Si did not affect the addition of leaf numbers [9,12]. Unfavourable environmental conditions such as low sunlight intensity influence si's effect on the number of leaves in this study because the Si element can help plant growth if the plant experiences biotic or abiotic stress [10].

3.3. Leaf area (cm²)
The type of Si fertilizer had no significant effect on the addition of the leaf area. The leaf area without Si fertilization treatment was relatively the same as the other treatments. This study's results are different from previous studies, which stated that Si application had a significant effect on the addition of leaf area [2,9]. Leaf area of lettuce given Si 3 ppm fertilizer, 29% increased leaf area than without added Si fertilizer. There was no effect of Si on leaf area in the present study due to limited sunlight because plant spacing too close (15 cm between plants).

3.4. Fresh weight (g)
The results of this study showed (table 1) that fresh plant weight was not affected by the type of Si fertilizer. In several studies, the addition of Si fertilizer has shown that it can increase lettuce's fresh weight [5,9]. The addition of 26% fertilizer can increase fresh plant weight. However, the increase in fresh weight produced by the addition of Si fertilizer is not significantly different than without Si fertilizer application. Plants that get less sunlight will experience etiolation symptoms and a decrease in biomass formation. The rainy season conditions during the research process affect the intensity of sunlight received by plants. The addition of Si elements to overcome environmental stress cannot help plant metabolic processes more efficiently because limited sunlight intensity cannot be substitute with applying Si to the plant [12].

![Figure 2. Visual appearance of lettuce plant after harvest (35 DAT)](image)

3.5. Shelf life at room temperature (day)
The measurement of the shelf life of fresh lettuce plants yields in the room temperature is to observe the Si element's role in influencing the transpiration rate. So the plants can maintain their freshness longer [13]. The results showed that Si fertilization did not affect the plant shelf life. In table 1, plants with smaller leaf area treatment B (1137.76 cm²) have a longer shelf life (4.4 days), while plants with a larger leaf area, treatment C (1540.27 cm²), have a short shelf life (3.8 days). The application of Si fertilizer from a concentration of 3 ppm, 6 ppm, and 9 ppm could not reduce the plant transpiration rate.
4. Conclusions
The results showed that silica sources' concentration affects the plant height (35 DAT) and the number of leaves (35 DAT). The leaf area parameter, fresh weight, and shelf life were not affected by silica sources concentration. The application of 6 ppm rice husk silica concentration increased the fresh weight of plants 26% higher than without the application of silica. The application of Si fertilizer in the cultivation process has not increased the shelf life of the harvest stored at room temperature

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