

Producing Fertiliser for Bok Choy Using Waste from Silica Water Filter

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Abstract

Water filter was created to make sure the people on this Earth are able to consume or use clean and fresh water, but once the water filter is not usable anymore, it is thrown away. Therefore, this research aims to reuse the water filter for other purposes. In this research, the waste was used for agriculture, repurposing it to enhance plant quality and growth. A silica water filter was taken and fabricated, processed to be combined with the current fertiliser to help the growth of the studied plant. The silica water was crushed and sieved until it reached 40 microns, and then mixed with fertiliser at 5%, 10% and 15%. It shows specimens with fertiliser mixed with silica had better height and more leaves count if compared to the specimens with no silica added.

1. Introduction

According to April Schroeder [1], the quantity of water utilised and the source water's quality influence how frequently it needs to be changed. As a rule of thumb, it should be changed every three to six months. After the period, the old water filter becomes unusable and is thrown away. Thus, this project aims to reduce the waste from the water filter and recycle it to become a fertiliser by extracting the silica (SiO_2). This project also aims to encourage sustainable activities for tackling environmental issues and improving long-term well-being for current and future generations.

The objective of the study was to make fertilizer from waste material from silica water filters. Silica waste was incorporated into the fertilizer at different concentrations (0%, 5%, 10%, and 15%). Soil pH and growth characteristics of Bok Choy plants grown in soil were researched regarding the influence of varying silica concentration.

2. Methodology

Methodology highlighted the flow of the research, procedure, and method on how to achieve the objectives of this research. The research was comparing the three silica's composition that mixed with fertiliser and studying the impact to growth of the plant. Fig. 1 shows the flow chart of this research.

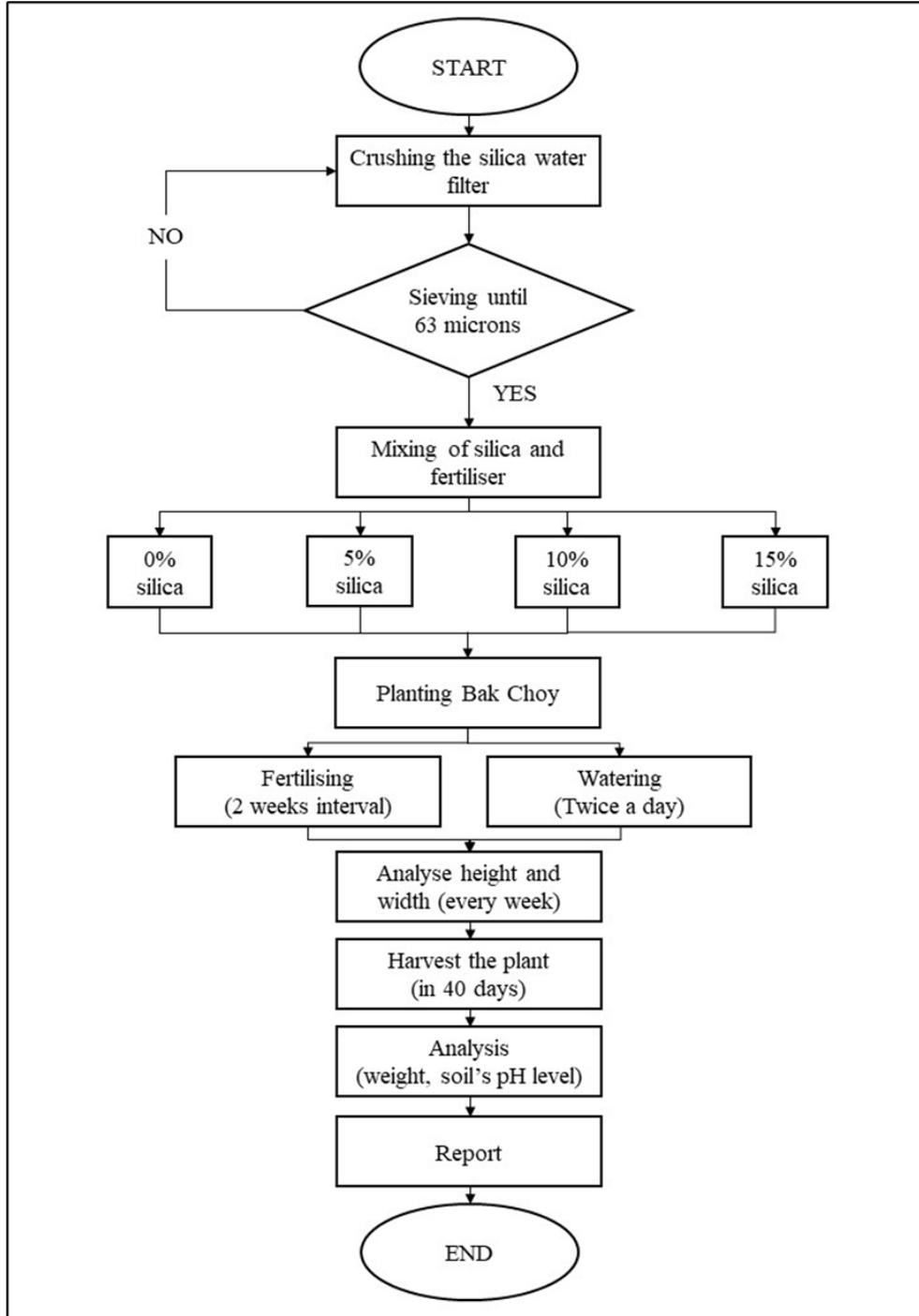


Fig. 1 Flowchart of the research

2.1 Sample Preparation

Firstly, the silica water must be crushed by a hammer first to get into the ball mill machine. To make it finer, the silica water filter was crushed then put into the ball mill machine in the Polymer Lab at UTHM. The ball mill was spun with a milling ball inside to make the powder finer and smaller. After that, the milled silica powder was then sieved by the sieve shaker, which was also at the same Polymer Lab.

For the sieving process, the powder that was crushed was then sieved until it reached 63 μm (micron, micrometre) or smaller. If some of the silica powder does not pass the 63 microns, it went through the crushing process again to reduce its size and repeat the sieving process. The objectives of the sieving process are to ensure that the silica that was mixed with the fertiliser reacts and has an impact on the plant.

2.2 Sampling

The mixing process is to combine the silica powder that was crushed with the chosen fertiliser. The ratio of the silica and the fertiliser is 0%, 5%, 10% and 15%. Table 1 shows the composition of the silica and Nitrogen-Potassium-Kalium (NPK) fertiliser that was mixed.

Table 1 *Composition of silica and NPK*

Sample	Composition of Silica, SiO_2	Composition of NPK
1	0%	100%
2	5%	95%
3	10%	90%
4	15%	85%

As mentioned before, there are three different compositions of silica water filter, and with a single sample without silica added as a comparison. The sampling approach is five plants for a single setup, a total of 20 samples. Table 2 shows the naming of each sample according to its parameters.

Table 2 *The specimen's name based on the sample*

Parameter	Sample Name
0% Silica	P11
	P12
	P13
	P14
	P15
5% Silica	P21
	P22
	P23
	P24
	P25
10% Silica	P31
	P32
	P33
	P34
	P35
15% Silica	P41
	P42
	P43
	P44
	P45

3. Results and Discussion

The planting process starts with growing the seedlings before they are transferred into a bigger pot. Transplanting seedlings to the main growing area starts off the plant's life with the best chance for growth, development, and maturity. The use of growing seedlings indoors or in seed trays also frees space and time as well since planting can be done selectively, and harvesting time is all year round.

Firstly, fill the seedling tray with the medium of the plant, in this case is peat moss. After that, make a hole on each section of the tray about 3 mm to 4 mm to put the seed inside and cover it with the peat moss. Make sure to water the seedlings gently to prevent the seeds from being carried away by the water. To prevent this, it is recommended to use a bottle spray as it can adjust the spread of the water and control the water as seedlings just need a small amount of water. Water the seedlings twice a day. After that, cover the seedling tray with opaque object such as plastic or polystyrene for a few days.

After a week of planting the seedlings, it can be transferred into bigger pots to let the plants continue to grow. Fill the pots with the plant media (peat moss) and make a hole wide enough to fill the seedlings. Make sure that the seedlings are in place the seedlings tightly to avoid it moves during watering. The specimens were watered twice a day, which in the morning and evening sufficiently. The fertilizer was applied fortnightly with 5g with the mixture of fertilizer and silica based on the composition respectively. Fig. 2 shows the specimen planted inside the greenhouse.



Fig.2 *The specimens after being transferred inside the greenhouse*

For this study the parameter was split up into two, growth parameter and quality parameter. For that reason, the results and the data of the plant led during its growing phase and after the plant was cropped was analysed for physical and dimension.

It focused more on how fast tall the plant growth was in the growth parameter. The height of each specimen was measured every week to observe the growth of the specimen by each week. Furthermore, the leaves count of the plant was measured because it is a data of visual key traits and the role of silica in the growth stage of the plant.

3.1 Height of Plant

Fig. 3 and Table 3 show the graph of the average height of the sample from Week 0 to Week 6 and the data table for the average height of each sample.



Fig. 3 Graph of average height of sample from Week 0 to Week 6

Table 3 The data table of the average height of the sample

AVERAGE HEIGHT (CM)							
SPECIMEN	WEEK 0	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
P1	2.06	3.60	6.26	7.10	8.00	8.00	8.00
P2	2.62	4.90	8.03	10.30	12.00	13.00	14.00
P3	3.02	4.36	7.16	8.33	10.67	12.90	16.00
P4	2.72	4.80	8.00	9.15	10.88	13.75	14.75

Based on the figure and table above, it shows that sample P3 has the highest average height at 16.00 cm, followed by P4 at 14.75 cm, next is P2 with a small difference at 14.00 cm, and last is P1, which was only at 8.00 cm.

All the samples had a similar trend from Week 0 to Week 3, indicating the specimens' successful growth. However, a sample which is P22 as shown in Fig. 4 has died after only two weeks. The specimen before was growing normally but then the stem of the specimen was gone, leaving only leaves. The reason why the specimen died may be due to overwatering.



Fig. 4 The specimen P22, which has died after two weeks

The weather during that week was quite rainy in the evening, which was absorbed by the soil. If the soil is flooded the plant fails to receive enough oxygen and the roots die, and the plant loses its strength. Slow growth at the back with very few leaves which appear to be yellowing, is a sign that the plant is over-watered. The dying roots rot and the plants are unable to feed from them and from water [2].

It is confirmed that the plants were overwatered due to the rain, which killed the roots. The yellowing leaves that were left were evidence that the root had died and killed the specimen. Nevertheless, the other samples were growing healthily without having any issues.

Unfortunately, all the samples had deteriorated, especially P1, after the third week of growth due to the mold growing at the bottom of the pot. This happens with the continuity of the rainy days from last week that promotes the mold growth. The presence of the mold was due to moisture or water from the rain, as the third week's weather had more rain than the second week.

With the rain in the evening and sometimes even at night, it creates a moist condition in the specimens' pots. The major requirement for mould growth is moisture. Mould needs moisture to grow and proliferate within the building or recommended space. At night, it may reach a temperature of 25°C or lower depending on the type of mold, as most of the mold is brought into being at a temperature of 20°-25°Cs. With nutrients from the peat soil, it was a source for them to make and reproduce [3]. Fig. 5 shows the mold growth on the specimens' pots.



Fig. 5 Mold growth under the specimen's pot

As shown in the figure above, there were several colours of mold grown at the bottom of the pot, which were white, brown, and black. The colour of the mold can determine the type of the mold and the cause of the fungus growth.

According to The Ultimate Mold Crew [4], White mold is not very often seen in the soil, but it does develop from spores. Overwatering provides an optimum condition in the soil for the brown fungus, provided there are spores in the preparation. This sort of fungi thrives in areas that have standing water or waterlogged soils. In short, the mold grows due to the spores in the environment or the specimens themselves. Bok choy bears round seeds in silique pods once it flowers. This natural mechanism can also serve for seed distribution.

The occurrence of grey mold signifies root rot or sometimes referred to as leaf rot in case of houseplants. The fungus *Botrytis* presents itself as grey spores around the soil line and in the most concentrated area of a plant's leaves. It is a fungus that grows on parts of plants that are normally already diseased or injured in one way or the other [4].

The mold under the pot was cleaned with water and a brush without any chemicals being used. The reason was to avoid the chemical reaction with the soil that may impact the growth of the soil. As stated, the specimen died due to damaged roots caused by the mold. The specimens that were infected were P13, P15, P21, P24, P31, P35, and P42, bringing the total number of specimens that died in this research to eight. Meanwhile, the other specimens were growing greatly where some specimens had grown up to 12 cm from the starting week of growing phase.

From Week 3 to Week 6, the specimens were growing healthily for P2, P3 and P4 after the mold attack. Unfortunately, P1 was still healing and starts to grow at the end of the research. There were also a few specimens died during the last three weeks which is P14, P34, P43 and P44. Those specimens were not able to be healed due to the unrepairable roots damage. Fig. 6 shows the specimens at Week 6.



Fig. 6 The specimens at Week 6

3.2 Leaves Count of Plant

Fig. 7 and Table 4 show the graph of average leaves count of sample from Week 0 to Week 6 and the data table for the leaves count of each sample.

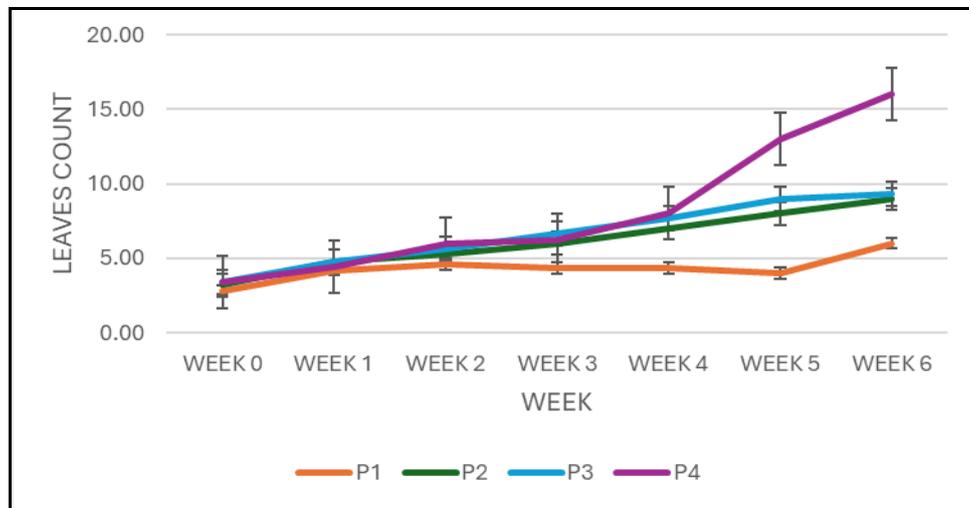


Fig. 7 Graph of average leaves count of sample from Week 0 to Week 6

Table 4 The data table of average height of sample

AVERAGE LEAVES COUNT							
SPECIMEN	WEEK 0	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
P1	2.80	4.20	4.60	4.33	4.33	4.00	6.00
P2	3.20	4.80	5.25	6.00	7.00	8.00	9.00
P3	3.40	4.80	5.60	6.67	7.67	9.00	9.33
P4	3.40	4.40	6.00	6.25	8.00	13.00	16.00

Based on the figure and table above, it shows that sample P4 has the highest average count of leaves at 16.00. Following P3 with 9.33, and P2 closes with 9.00. Same as the average height ranking, P1 was also in last place for average leaf height with only 6.00.

The trends of the leaves count were followed by the trend of average height, where from Week 0 to Week 2, they were growing healthily with the average leaves count of each sample exceeding 4.00 and even reaching 6.00. As discussed before, the mold growth occurred at Week 3, but it does not affect the number of leaves for the samples except P1. During that week, only P1 count leaves were decreased, while others had sprouted new leaves.

The plant's leaves start dying when they start to turn yellowish, and after a while, they turn brown before it was crumpled and die. There are several factors that would be the causes, including overwatering and mold growth, as was discussed before.

The main reasons for the leaves of the specimen dying may be due to acclimation and the natural process of the specimens [5]. The power to acclimate or adapt to environmental changes over the lifetime of the individual. Plants retain this ability to cope with the continuous variation in ambient conditions to which sessile organisms are exposed [6]. With the change of weather from sunny to rainy almost every day, the specimens may not be able to adapt and survive the extreme changes in temperature.

The natural process of the leaves to die was called leaf senescence. It was the last stage of leaf development and is of fundamental importance to a plant's fitness, as it allows relocation of nutrients from leaves to seeds of developing fruits. Leaf senescence is a highly regulated program of cellular, tissue, organ and organism levels, which is directed at coordinating action [7]. The leaves sacrifice themselves to ensure that new leaves sprout and that the nutrients are moved to the other parts of the plants.

After Week 4, P1's specimen has reduced in leaves due to repairing itself to continue to grow until Week 5. At Week 6, P1 seems to have sprouted new leaves, indicating that it was healed from the fungus and continues to grow. For P2 and P3, their trends were quite similar and resulted in almost similar values in leaves count. However, P4's specimen burst in leaves count starting from Week 4 to Week 6.

Since all the specimens were in the same environment and watering quantities, the P4 specimens, especially P44, underwent major hormonal changes. Environmental cues trigger hormonal changes that in turn dictate which plant cells should grow into and when: This works so that the plant is slightly changed by a change in the environment [8]. Although some of the other specimens were battling to survive in the extreme weather changes, P44 were able to adapt and had an explosive growth, sprouting a lot of new leaves with the support of the silica content within the soil.

4. Conclusion

In conclusion, the usage of waste from the production of silica water filters for making fertilizers is a sustainable management of waste, which results in the development of important agricultural produce. This process depends on compounding it with other materials likely to complement the silica and effective control of pH and nutrient levels. As this method is friendly to the environment and economical, as it minimizes wastes while coming up with a useful product, it is important that the quality of the fertilizer be checked and tested for quality and nutrient content frequently.

Based on the result discussed, adding silica to the fertiliser promotes the growth of the specimens, which is bok choy for this research. It helps the plants to grow higher and sprout more new healthy leaves if compared to the sample with only fertiliser. In addition, the silica was able to fight any fungus and does not attract any pests at all. Furthermore, it does not change the acidity or alkalinity of the soil after being applied three times to the soil. The method thus reveals a prospect in terms of upscaling for commercialization especially within zones with a high endowment of water treatment industries. However, bear in mind the local legislation concerning the recycling of waste and the quality of the fertilizers produced. These specialty fertiliser products could be developed into a more significant part of environmentally friendly farming as the author continues to conduct research on how to improve the effectiveness of the silica filter waste products.

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Conflict of Interest

There is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: study conception and design: Author 1, Author 2; data collection: Author 1; analysis and interpretation of results: Author 1, Author 2.; draft manuscript preparation: Author 1, Author 2. All authors reviewed the results and approved the final version of the manuscript.

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