The Effect of Silicon Fertilizer on The Growth of Chives

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Abstract: Potted plants of chives to explore the growth effects of applying silicon fertilizer with 5 levels (0,180,360,540,720 mg/kg) for 3 weeks. Variables measured of plant development included fresh weight of whole plants, leaves, stalks; plant height; moisture and chlorophyll content in leaves. The results showed that the application of silicon fertilizer during 180-540 mg/kg concentration could improve the biomass weight and the growth height, increase chlorophyll and moisture content of chives leaves. The optimum effective silica concentration was 360 mg/kg, whereas the plants growth were decreased and even negatively affected with the increase of silica concentration to 720 mg/kg. This study provided a research foundation for the promotion of silicon fertilizer in the cultivation of chives and the further broadening of the application of silicon fertilizer. Funded by: Key Laboratory of Environmental Biotechnology (XMUT), Fujian Province University.

1. Introduction
Silicon fertilizer is a kind of mineral fertilizer and weakly alkaline, slightly soluble in water. Japanese scientists began to research systematically in the 1950s and have been widely used as a new type of fertilizer [1]. Then Korea, Philippines, Taiwan province and some countries in southeast Asia introduced the technology to promote and apply. Since then, silicon fertilizer has been recognized as the soil required nutrient to plant growth after nitrogen, phosphorus and potassium, and it has been listed as one of the four major elements for the yield increase of rice and other gramineous plants [2]-[5].

The started research on silicon fertilizer in China was in 1970s to 1980s, then the research was accelerated [6]. In 1996, the silicon fertilizer research center was set up in Henan province and responsible for the formulation of silicon fertilizer standards. The first "silicon and agriculture" research conference was held in the United States in 1999, which meant that the world's agriculture and fertilizer industries began to pay attention to silicon fertilizer. In recent years, studies on the effects of application of silicon fertilizer on rice have been particularly outstanding in China [7]-[10] and it's also considered to be the second green revolution after hybrid rice.

The mechanism and effect of silicon fertilizer to plant was it could promote the formation silicide cells and thicken cell wall after absorbed silicon fertilizer [1], [4]-[6]. Therefore, it was beneficial for stems and leaves to straighten and increase leaf photosynthesis, enhance the capacity of crops resistant to pests [11]; Silicated cells could effectively regulate stomat and water transpiration of crops to improve drought resistance [12]. Supplement Silicon fertilizer could effectively prevent and control heavy metal pollution to crops and improve the ability to resist salt and alkali [13]-[15]. The application of
silicon fertilizer to rice could regulate the nutrient supply, increase roots oxidative power, promote the operation of carbohydrates and the growth of biomass [16]-[17].

Chive (*allium schoenoprasum* L.) is a perennial herbaceous plants, belonging to the family Liliaceae. It is an important condiment, which has both edible and medicinal functions. However, because of the leaves' hollow tubular shape and high water content, they are fragile and easy to break down and cannot be stored for long time. At the same time, silicon is a quality element, which can improve the quality of agricultural products, so that the color, smell and taste become good, and beneficial to storage and transportation. But the application of silicon fertilizer in the cultivation of chives has not been reported. In this paper, the effect of appropriate silicon fertilizer on the growth of chives is investigated, which provides a reference for improving the quality of planted chives.

2. Materials and methods

2.1. Materials and equipments

Powdered silicon fertilizer was purchased in the market with an effective silicon content of 180 mg/g; The planting Soil was digged from local vegetable garden in Xiamen city, in which the effective Silicon was about 46-48 mg/kg. Ultraviolet visible spectrophotometer (UV 3200), electronic balance (ML204T), and oven (dhg-9146a) would be used in tests.

2.2 Experimental methods

2.2.1 Applying silicon fertilizer to cultivate chives

Chive bulbs Evenly sized were potted in 20 cm diameter pot containing 2kg of garden soil, each potted 15. After the spring onion germinated 1-2cm, silicon fertilizer was dissolved in 200ml water and fertilize to the soil based on 4 groups of concentration as (180,360,540,720 mg/kg), the control group no fertilization, 3 duplications per team of tests. All potted plants were cultured in greenhouse, watered at the right time, and the growth of plants were observed and recorded every day. After fertilization treated for 3 weeks, the plant biomass, height, water content and chlorophyll of chives were measured. The experiment was conducted three batches. The first batch was planted in autumn, the second in winter and the third in spring. Then the test statistics were carried out, and the average value of each batch of data was taken.

2.2.2 Measure plant height

The growth of chives was observed and recorded every day, and 5 chives were randomly selected to calculated the height of above ground growth after 3 weeks.

2.2.3 Measure plant biomass

After 3 weeks of treatment with different concentration of silicon fertilizer, the chives were removed gently from the basin. Five chives were randomly selected and the whole plant, the ground section (stems and leaves) and 10 leaves (8cm long) were weighed randomly, and the relative biomass was obtained separately.

2.2.4 Determine the moisture content in leaf

Ten leaves treated with different concentrations were harvested randomly, and then placed in oven at 105 °C for 2 h to dry weight, recorded its quality. The wet weight and dry weight was obtained by weighing 1/10000 electronic balance, and the moisture content of chives was calculated.

2.2.5 Determine chlorophyll content

Chopped leaves 0.2g were grounded into homogenate with 95% ethanol to extract the chlorophyll, and then filtered into 25ml volumetric flask. The absorbance of the extraction solution was determined and recorded at 665nm and 649nm by spectrophotometer with 95% ethanol as reference solution.
According to the formula, the content of chlorophyll a and chlorophyll b were calculated respectively, and the total content of chlorophyll was obtained.

3. Results

3.1. Measurement of growth height

Figure 1 showed the average height of growth of each batch of chives over 3 weeks. The average height of the control group was 8.83 cm, while the treatment groups height were increased by 21.74%, 44.05%, 24.58% and 12.34% respectively. The growth height showed a trend of first increasing and then decreasing with the increase of the amount of silicon fertilizer, among which 360mg/kg of silicon fertilizer was applied for the best growth, and the height was nearly 1.5 times higher than that of non-silicon fertilizer. It was also observed that the leaves were blown off by the wind with silicon fertilizer was lower than that of the control group, indicated that silicon fertilizer could promote the growth of chives and improve the ability of anti-fracture.

![Figure 1. The height of chives](image1)

3.2. Measurement of biomass weight

![Figure 2. Biomass weight of chives](image2)
In order to explore the effect of silicon fertilizer on chives, the biomass of the whole plant, the aboveground part and the leaves were measured (grown in spring). As could be seen from FIG. 2, the same growth rules were observed in all three indexes of chives applied with different concentration of silicon fertilizer. The net biomass weight of the whole plant increased by 14.56%, 34.47%, 14.56% and 11.63%, the aboveground parts (stem and leaf) increased by 10.26%, 35.9%, 23.08% and 11.11%, and the leaves increased by 6.49%, 14.05%, 3.78% and 1.62% respectively. The relative increase in biomass which applied 360 mg/kg silicon fertilizer was the highest. In contrast, silicon fertilizer contributed more to allium roots than leaves.

When the amount of silicon fertilizer was greater or less than 360 mg/kg, there was a certain decline in biomass. However, the biomass of the control group was the lowest, indicated that the effect of silicon fertilizer on the biomass of chives was relatively obvious.

3.3 Determination of water content in leaves
As could be seen from FIG. 3, the moisture content in control group leaves reached 87%–90% and its related to season, the highest water rate was in spring(89.02%) , followed by winter(88.25%) and the lowest in autumn(86.97%) .

![Figure 3. The water content in leaves](image)

Appropriate supplementary silicon fertilizer could improve the leaf water content, and the plant treated with 360 mg/kg silicon fertilizer had the highest water content in leaves. When high concentration silicon fertilizer was applied (720 mg/kg), the water content decreased. In particular, during the drier autumn and winter, the water-retaining effect of application of silicon fertilizer was significantly higher than in spring. It was also found that when cutting the leaves treated 360 mg/kg, the mucous material in tubular leaf was thicker than that of other chives significantly. It's probably the soluble sugar in the leaf, which was the ability to infiltrate a plant's cell and regulate it to protect the water. It also proved on the other hand that silicon fertilizer had the function of enhance the drought resistance of plants.

3.4 Determination of chlorophyll content in leaves
FIG. 4 showed the effect of silicon fertilizer on chlorophyll in the leaves of chives. After the application of 360 mg/kg silicon fertilizer, the content of chlorophyll increased by 28.75% compared with the control group, followed by 540mg/kg, up by 16.54%. When the application of silicon fertilizer was too high (720mg/kg), the increase was only 2.77%. At the same time, it could be observed that some leaves of chives turned yellow, which may be caused by too high concentration of silicon fertilizer applied to burn seedlings.
4. Conclusion
The study indicated that the application of a certain concentration of silicon fertilizer had a good effect on the growth of chives. The plant height, total biomass and chlorophyll content increased with the increase of silicon fertilizer application in the range of 180-540 mg/g silicon content. However, when the effective silicon content was 720mg/g, it would inhibit the growth of chives. The optimum dosage was 360 mg/kg, compared with the control group, the plant height increased by 44.05%, the total biomass weight increased by 35.9%, and chlorophyll content increased by 28.75%. In addition, applying silicon fertilizer could promote the capacity for water conservation of chives to improve the drought resistance and the anti-fracture ability.

5. References
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