

Effects of Different Methods of Accelerating Germination on Early Growth of Spinach

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Abstract

Because spinach seeds have a hard seed coat structure, if direct sowing is adopted without seed treatment in production and cultivation, it is very easy to cause poor seed emergence, resulting in a certain degree of yield reduction. Studying the germination conditions of spinach seeds under different conditions is of great significance for the quality of spinach seed germination and farmers' sowing and production. In this study, two methods were used to treat spinach seeds and observe their germination. The results show that the two methods are significantly better than the control, indicating that H₂O₂ soaking and warm soup soaking can promote the germination of spinach seeds. The effect of 20% H₂O₂ soaking is the best. Dioxygen water can also release oxygen in aqueous solution, which is very beneficial to the growth of Spinach Seedlings. Therefore, it is suggested that spinach seeds should be soaked in 20% H₂O₂ or warm water in combination with the actual production, so as to promote the germination of spinach seeds under appropriate temperature conditions.

Keywords

Spinach; Germination; Warm Soup; 20% H₂O₂.

1. Introduction

Spinach has been the Chinese people's favorite vegetable since ancient times, it is nutritious and widely cultivated. Spinach is rich in all kinds of nutrients, and vitamin A is among the highest among all kinds of vegetables. In particular, iron, which is needed for human hematopoiesis, is higher in spinach than in most other vegetables. At one time, spinach was used as an auxiliary treatment for anemia in China. Spinach also contains high dietary fiber, regular consumption is good for gastrointestinal diseases. It can improve gout, constipation, skin diseases and other diseases. As of 2022, China had more than 600,000 square hectares of spinach under cultivation. Spinach production accounted for 5 % of the total vegetable production. It has a certain status in our vegetable industry. The development of spinach has a profound effect on the development of our vegetable industry. Although the development of spinach in China is much better than before the founding of the nation, the domestic variety still lacks competitiveness in the international market [1].

In recent years, the global weather changes abnormally. Unusual weather often appears in many places of our country, which is very unfavorable to the germination and growth of horticultural crops. Germination of spinach seeds can be affected by different conditions. Obtaining the optimal germination conditions can save time cost and increase yield in agricultural production. Selecting suitable treatment methods in production can improve the germination rate and growth potential of spinach seeds, which is beneficial to the growth of spinach.

According to the research of Xiaofeng Chen (2018), the seeds can be soaked in clean water for 24 hours before sowing to achieve the effect of accelerating germination, or the technology of

accelerating germination at low temperature can be adopted to ensure a higher budding rate. The seeds were soaked in cold water for 10-24 hours, and then placed in 16-21 °C environment to accelerate germination. Generally, after 1-4 days, the germination rates of the two treatments were 88.9% and 91.1%, respectively. There was no significant difference between the two treatments, but there was significant difference with other treatments. It can be seen that the germination rate of spinach seeds can be significantly increased by soaking seeds and accelerating germination [2].

Dan Wang et al. (2022) studied the treatment of spinulated and non-spinulated spinach with different temperature, light, gibberellin (GA) concentration and 6-benzylaminoadenine (6-BA) concentration, and determined the optimal germination condition based on germination rate. The results showed that the optimal soaking temperature was 20 °C, the light condition was more conducive to germination, the optimal GA soaking concentration was 200 mg/L, and the optimal 6-BA soaking concentration was 70 mg/L. The optimum soaking temperature of spine-free spinach was 20 °C, and the full light condition was more conducive to its germination. The optimum GA soaking concentration was 100 mg/L, and the optimum 6-BA soaking concentration was 80 mg/L. This study provides experimental and theoretical basis for basic research on improving spinach yield and spinach seed germination [3].

This study explores the methods to promote the rapid germination of spinach seeds and good growth at the early stage of growth, so as to provide a theoretical basis for spinach farmers or enterprises.

2. Materials and Methods

2.1. Source of Spinach Seed

Shandong leaflet spinach, bought by taobao.

2.2. Seed Treatment

(1) Soaking in 20% H₂O₂: Soak 20% H₂O₂ aqueous solution for 60 min; After the treatment, clean the surface solution of the seeds with clean water, spread the seeds evenly on the paper towel, and then lay the paper towel in the plastic basin after soaking, and leave for 3 days. Sprinkle 20 mL of water daily to ensure humidity.

(2) Soaking in warm soup: Soak spinach seeds in warm water at 55-60 °C for 15 minutes, extract the controlled moisture, and then lay them on paper towels. After the paper towel is moistened, transfer the spinach seeds to a plastic basin, spread evenly and leave at room temperature for 3 days. During this period, check and record the germination of seeds regularly, and calculate the germination rate and germination potential. In addition, sprinkle 20 mL of water daily to keep the spinach seeds moist.

(3) Control group: The spinach seeds haven't been processed.

2.3. Sowing

Sow after all seeds have germinated.

Vegetative soil is spread in the seedling tray. the vegetative soil is spread evenly on the seedling tray and irrigated to fully wet (dripping hands and non-sticky hands). When sowing, first of all, the soil in the fertilizer tray should be tamped, and the seeds should be filled with 1-2 cm soil, so as to facilitate the root breathable. Plant a spinach seed in each square of the seedling plate.

2.4. Measurement of Initial Indicators of Spinach Growth

Spinach seeds were processed as described in 2.1, and plant height and leaf length were measured when all primary leaves were expanded.

The height of the plant is measured by the distance from the ground where the spinach grows to the top of the spinach plant. Measurement method of spinach plant height was as following: Use a long enough thread and a heavy object. Attach a weight to one end of the wire. Lower the weight and place the rope at the height of the plant under test. When measuring, make sure that the weight hangs down to the plane of the plant root, while keeping the thin line upright. Write down the height of the plant on a thin line. The height of the plant can be found by measuring a thin line with a ruler.

The leaf length of spinach is measured by subtracting stem length from plant height.

SPSS 20 software was used to analyze the significance of soil breaking rate, plant height and leaf length between different experimental groups and the control group.

3. Results

3.1. Soil Breaking Rate at the Initial Stage of Spinach Growth

After sowing, after ten days of management and observation, the continuous ten days of spinach soil breaking situation was recorded (Figure 1). The experimental results showed that the two methods of seed soaking in warm water and hydrogen peroxide treatment could significantly accelerate the breaking of spinach seeds: (1) the breaking rate of the control group was not 0.00% on the third day, the average breaking rate of the third day after warm water immersion was 48.00%, and the average breaking rate of the third day after 20% hydrogen peroxide treatment was 51.33%; (2) The soil breaking rate of the control group was only 27.67% on the 10th day, the average soil breaking rate was 80.00% on the 10th day after soaking seeds in warm water, and the average soil breaking rate was 76.67% on the 10th day after 20% hydrogen peroxide treatment. In the whole process of soil breaking and growth, compared with the control group, the soil breaking rate of spinach treated with warm water and hydrogen peroxide increased significantly ($p < 0.01$). There was no significant difference in soil breaking rate between the two methods ($p > 0.05$).

Compared with warm water soaking and hydrogen peroxide treatment, hydrogen peroxide treatment had a better effect on improving the soil breaking rate of spinach seeds in the early stage (the first 4 days). The seed soaked in warm water had a better effect on improving the seed breaking rate of spinach in the later period (after 6 days).

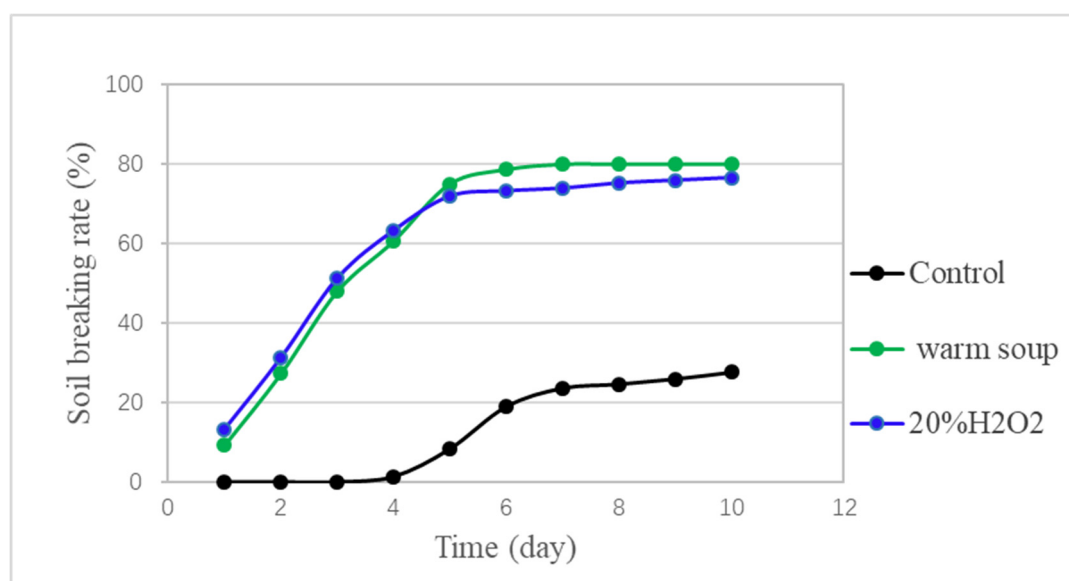


Fig 1. Effects of different treatments on soil breaking rate of Spinach

3.2. Leaf Length of Spinach at the Early Stage of Growth

On the third day, the leaf length of spinach in the control group was 0 cm (the control group had not broken the ground). 45.25% leaves of spinach after soaking in warm water was less than 1 cm (on average), 35.61% of the leaves were longer than 2 cm, and 19.14% of the leaves were between 1-2 cm. Most of the leaves of spinach treated with 20% hydrogen peroxide were longer than 2 cm (the average proportion was 56.25%), 28.10% were between 1-2 cm, and 15.65% were less than 1 cm (Figure 2). The experimental results showed that at the early stage of spinach growth, hydrogen peroxide treatment could significantly promote leaf growth, and the promoting effect was better than that of seed soaked with warm water.

In the early stage of spinach growth, most of the spinach leaves in the control group were less than 1 cm in length (the average on the 7th day was 59.82%, and the average on the 10th day was 63.59%). Most of the spinach leaves in the warm water immersion group were longer than 2 cm (the average on the 7th day was 48.37%, and the average on the 10th day was 51.13%). The length of spinach leaves in 20% hydrogen peroxide treatment group was also more than 2 cm (the average on the 7th day was 65.28%, and the average on the 10th day was 58.61%) (Figure 2). These results indicated that both warm water and hydrogen peroxide treatment could significantly promote the growth of spinach true leaves ($p < 0.01$).

At the early stage of spinach growth (1-10 days), the proportion of spinach with leaf length greater than 2 cm in the warm water immersion group increased gradually (from 35.61% on the 3rd day to 51.13% on the 10th day). The proportion of spinach with leaf length greater than 2 cm in 20% hydrogen peroxide treatment group also increased gradually (from 56.25% on the third day to 58.61% on the tenth day) (Figure 2). However, the proportion of spinach with leaves longer than 2 cm in the 20% hydrogen peroxide treatment group was always higher than that in the warm water immersion group. The experimental results showed that the effect of hydrogen peroxide treatment on the growth of spinach true leaves was better than that of warm water immersion method, but the difference was not significant ($p > 0.05$).

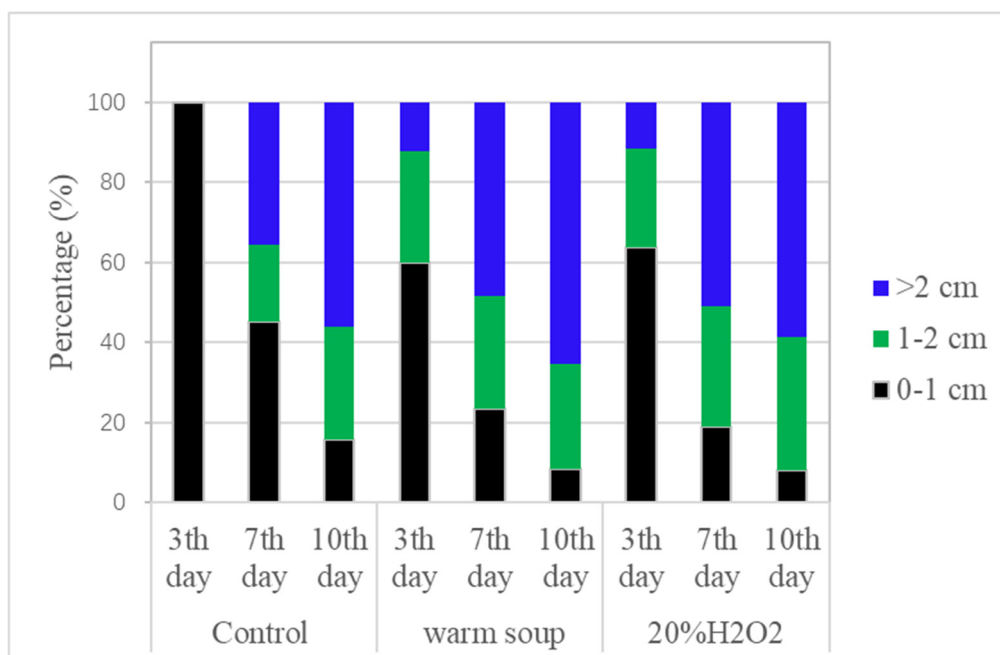


Fig 2. Distribution percentage of spinach leaf length in different treatments during early stage

3.3. Plant Height of Spinach at the Early Stage of Growth

On the third day, the plant height of spinach in the control group was 0 cm (the control group had not broken ground). The plant height of spinach after soaking in warm water was less than

3 cm (the average proportion was 61.61%), 5.53% of the plants were taller than 5 cm, and 32.86% of the plants were between 3-5 cm. The plant height of spinach treated with 20% hydrogen peroxide was also less than 3 cm (the average proportion was 62.21%), 31.33% of the plants were between 3-5 cm, and 6.46% of the plants were taller than 5 cm (Figure 3). The experimental results showed that the two methods of seed soaking in warm water and hydrogen peroxide treatment could promote the early growth of spinach, and the two methods had little difference in promoting effect.

On the 7th and 10th day, the proportion of spinach plants taller than 3 cm in the control group was 74.71% and 87.41%, respectively. The proportion of spinach plants taller than 3 cm in warm water immersion group was 75.88% and 92.98%, respectively. The proportion of spinach plants taller than 3 cm in 20% hydrogen peroxide treatment group was 83.76% and 92.85%, respectively (Figure 3). The proportion of spinach plants larger than 5 cm in the control group was 38.90% and 53.98%, respectively. 47.96% and 67.28% in warm water immersion group, respectively. The rates of 20% hydrogen peroxide treatment group were 55.51% and 59.90%, respectively. These results indicated that both the warm water soaking and hydrogen peroxide treatment could promote the initial growth of spinach, and the promoting effect was extremely significant ($p < 0.01$).

At the early stage of spinach growth (1-10 days), the proportion of spinach plants larger than 5 cm in the warm water immersion group increased gradually (from 5.53% on the third day to 67.28% on the 10th day). The proportion of spinach with leaf length greater than 5 cm in the 20% hydrogen peroxide treatment group also increased gradually (from 6.46% on day 3 to 59.90% on day 10) (Figure 3). The proportion of spinach with leaf length greater than 5 cm in 20% hydrogen peroxide treatment group was higher than that in warm water immersion group at the first 7 days, but it was lower than that in warm water immersion group at the 10th day. The experimental results showed that there was no significant difference in the promoting effects of the two methods of seed soaking in warm water and hydrogen peroxide on spinach plant height ($p > 0.05$).

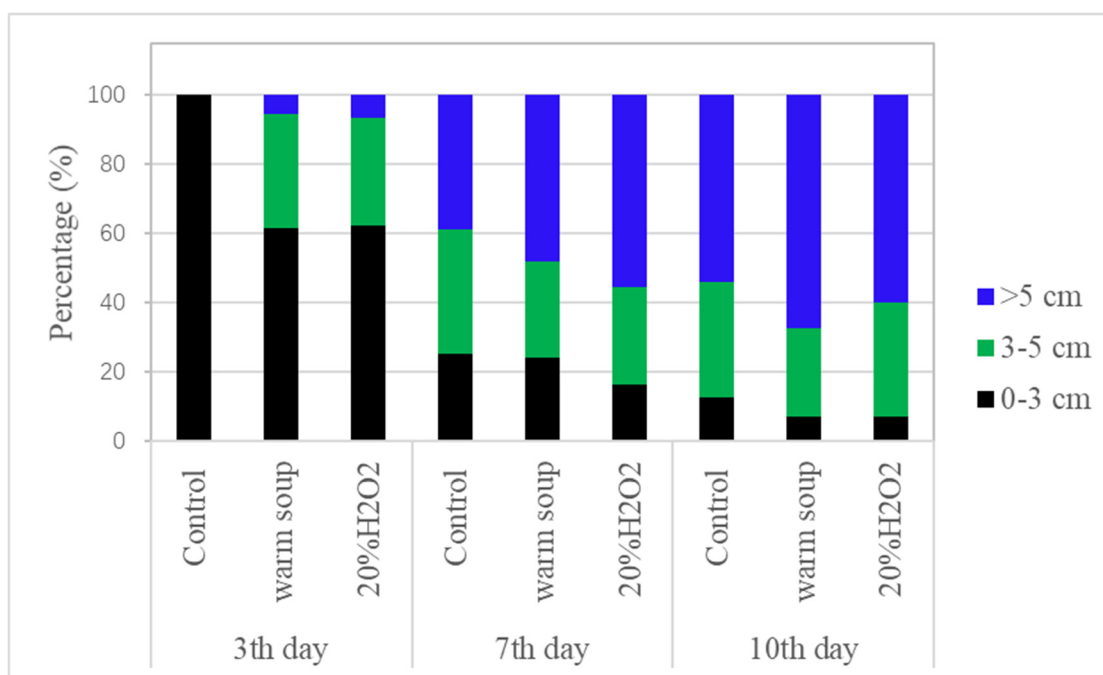


Fig 3. Distribution percentage of spinach plant height in different treatments during early stage

4. Discussion

The results of this experiment showed that, compared with the control group, the soil breaking rate of spinach after soaking seeds in warm water and hydrogen peroxide treatment was significantly increased. These results indicated that the two methods of seed soaking in warm water and hydrogen peroxide treatment could promote the germination of spinach seeds. This is consistent with previous experimental results. Xiaofeng Chen et al. (2018) treated spinach seeds with warm water and soaked in hydrogen peroxide, and the experimental results showed that the method of hydrogen peroxide treatment and soaked in warm water could promote spinach germination/increase germination rate by destroying seed coat [2].

Guie Sun (1987) treated spinach seeds with 20% hydrogen peroxide, and the germination rate was 6% on the second day, 20.0% on the third day, and 80.0% on the seventh day [4]. Xiaofeng Chen et al. (2018) treated spinach seeds with 20% hydrogen peroxide, and the soil breaking rate of spinach was 56.2-93.5% after 14 days [2]. Dan Wang et al. (2022) treated spinach seeds with 20% hydrogen peroxide, and the soil breaking rate of spinach was 90.6%, 88.4% and 84.8% after 7 days [3]. In this experiment, spinach seeds were treated with 20% hydrogen peroxide, and the average soil breaking rate was 76.67% on the 10th day. In this experiment, the soil breaking rate of spinach seeds treated with hydrogen peroxide was lower than that in the reference. The possible reason is that most of the experimental time in the literature is from August to September, namely autumn. At that time, the temperature was gradually dropping. Our experiment began on April 1, and the temperature was gradually increasing, which had certain inhibition and influence on the growth of spinach.

Chongzhi Li (2012) promoted the germination of spinach by warm water treatment, and the germination rates were 90.6%, 88.4% and 70.8% after 14 days [5]. Xiaofeng Chen et al. (2018) promoted the germination of spinach by the way of warm water treatment, and after a few days, the breaking rate of spinach was 52.5-76.4% [2]. Jian Liu (2018) promoted the germination of spinach by treatment with warm water, and the germination rate of spinach was 38.2-70.5% after 7 days [6]. In this experiment, by the method of warm water treatment, the spinach soil breaking rate was 80.0% on the 10th day. This experimental result is close to the results in the literature. We speculate that the germination of spinach seeds after soaking in warm water is more stable and less susceptible to the influence of external environment.

5. Conclusion

In this study, Shandong spinach was used as experimental material to study the effects of different seed treatments on the initial growth stage of spinach. Through comparison control group with warm soup soaking group and hydrogen peroxide treatment group, it was found that the two treatment methods could significantly increase the soil breaking rate of spinach, and can significantly promote the early stage growth of spinach. Therefore, in actual production, according to the specific local conditions, we can choose warm soup soaking seed treatment or hydrogen peroxide treatment.

Acknowledgments

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