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Ultrasound on Seedling Growth of Wheat under Drought Stress Effects

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Abstract

This study used different intensity ultrasound treatments, wheat seedlings in the germination energy, germination rate, growth potential, root length, and number of lateral roots optimal radiation dose selection. Studied under drought stress were the optimal dose of radiation treatment of wheat seedling leaf relative water content (RWC), protein content, Methane Dicarboxylic Aldehyde (MDA) content, relative conductivity, Superoxide dismutase (SOD) activity, and the impact of amylase activity. Studies have shown that after ultrasonic treatment enhanced drought resistance of wheat seedlings, alleviate drought stress on wheat seedling injury to 65 W 15 min ultrasonic treatment works best.

Keywords

Drought Stress, Ultrasound, Drought Resistance

1. Introduction

Wheat, regarded as one of the entire world's most important food crops, is widely grown in the world. About a third of the entire world's population mainly feeds on wheat, of which yield directly relates to the world food security. However, seventy percent of the entire world's wheat growing region distributes in arid and semiarid region [1] [2]; drought has become one of the important factors that threaten wheat production. With the aggravation of the global water crisis, the seriousness of the problem is further aggravated [3]. And if the wheat can resist drought stress without affecting its production, the solution of the problem on food for the whole world will be a breakthrough.

In recent years, the application of ultrasonic technology in the correlative industry is more and more widely, which is also very widely used in agriculture [4] [5]. Some studies have shown that low intensity ultrasound has effects on promoting grain crop seed germination and increasing yield [4].

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This research treats wheat seed with the ultrasonic and measure morphology and related physiological indexes of wheat [6], such as relative water content, relative electric conductivity, protein content, SOD activity and MDA content. Beyond that, it also studies the ultrasonic effects on the drought resistance of wheat under drought stress. In the experiment, we will select the proper coefficient of ultrasonic to provide a new and feasible method for alleviating the effects of drought on wheat seedling.

2. Materials and Methods

Wheat seeds (*Triticum aestivum L. cv.* Lin optimal 2069) were selected as the materials.

2.1. Filtration of Ultrasound Doses

First, select plump and consistent to the size of the wheat seed. According to the existing research, we process the wheat seed with 195 w, 130 w, 65 w ultrasonic treating 30 min and 15 min respectively. The distance between the ultrasound Emitters and the seed was 10 cm. Meanwhile let unprocessed wheat seeds and the processed wheat grow together. Finally, measure wheat germination potential, germination rate, growth potential and root length after 3 day cultivation.

2.2. Drought Treatment

Give three days alike treatments that drought stress, soil conditions, temperature, fertilizer and so on, to the optimal treatment group and control group of wheat seedlings in growth after a week.

2.3. Measurement of Growth Index

Measure wheat germination potential, germination rate, growth potential, root length, lateral root number after 3 day cultivation. Germination rate indicate the seed germination capacity, using the type calculation to measure: germination rate = (germinating seed grain number divide selected seed grain number) by 100%. Germination potential indicates the germination of seeds germination speed and germination uniformity, the strength of the seed vigor, using the type calculation: the germination = (germinating seed grain number divide the selected seed grain number in certain time) by 100%. Growth potential is pointed to plant growth and development degree, while the leaf area is an important symbol of crop growth potential strength, using the type calculation to measure:square meters leaf area multiply plant height with a development period. so we respectively use direct method to calculate and measure various index.

2.4. Measurement of Physiological Indexes

Measure the physiological indexes of wheat seedlings, which is processed by drought. Measurement of the relative water content (RWC) and relative electric conductivity respectively refer to Zhi and Farshadfar's method [7] [8], Ai Kuichen method [9]. The measurement of MDA content use thiobarbituric acid (TBARS) method [10] [11], using $\mu mol \cdot g^{-1}$ FW to indicate MDA content. The measurement of protein content refer to Wei [12], expressing protein content in mg/mL FW; The measurement of SOD activity refer to Zhu [13], regarding that restrain nitroblue tetrazolium (NBT) light to restore by 50% per minute as one unit of enzyme activity (U), and expressing the activity of enzyme in $U \cdot g^{-1}$ FW$\cdot min^{-1}$. The measurement of amylase refer to Zhu [13], expressing the activity of amylase in mg/g·min.

3. Results

3.1. The Influence of Different Ultrasonic Processing on Wheat Seedling Growth

As shown in **Figure 1** and **Figure 2**, compared with the control group, wheat seedling germination potential, germination rate, growth potential and root length were significantly reduced after the 195 w ultrasonic processing; By the 130 w ultrasonieat processing, wheat seedling germination potential, germination rate, growth potential and root length were slightly lower than the control group. By the 65 w ultrasonic processing after 15 min, wheat seedling germination potential, germination rate, growth potential and root length were higher than that of control group, which showed that low intensity ultrasound processing can promote the germination of wheat seed.

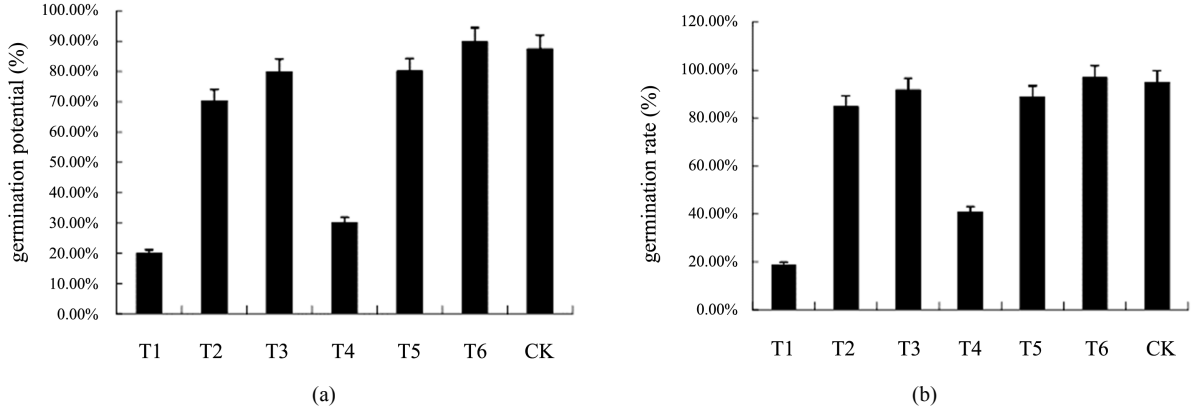

Figure 1. The influence of germination potential (a) and germination rate (b) by different treatment.

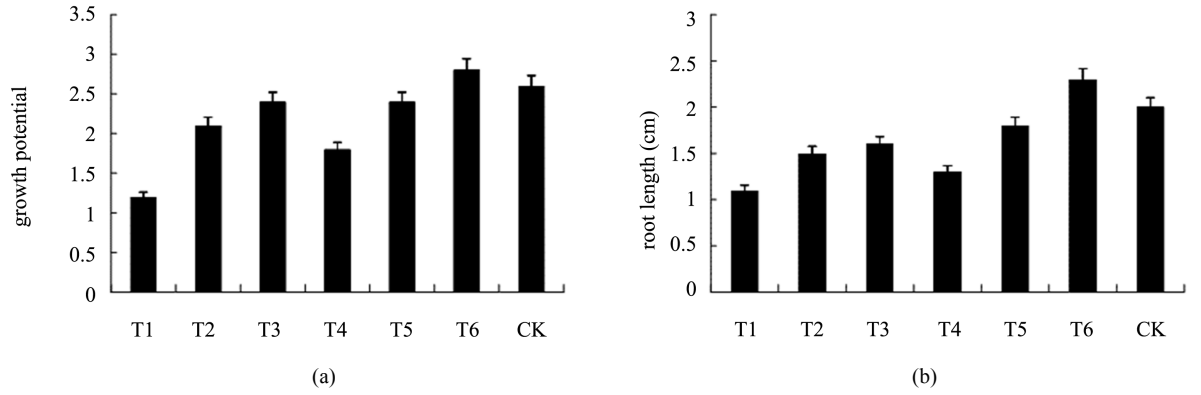

Figure 2. The influence of growth potential (a) and root length (b) by different treatment.

According to the above results, we could find: compared with other groups, 65 w, 15 min processing wheat seedling had highly ability in growth, but not necessarily the optimal dose and time, which still can was selected as the experimental conditions. Then, the control group and 65 w, 15 min processing wheat seedling were in drought stress at the same time , and measured corresponding physiological indexes to study the dose of ultrasonic effect on wheat seedling under drought stress .

3.2. The Influence of 65 w, 15 min Ultrasonic Processing on the Relative Water Content and Protein Content of Wheat Seedlings under Drought Stress

A large number of studies have shown that high leaf relative water content of wheat has higher drought resistance capability [7]-[14]. As shown in **Figure 3(a)**, apparently, the experimental group of wheat leaf relative water content is higher than the control group, the increasing quantity is approximately thirty percent. Drought stress could restrain protein synthesis, induce protein degradation, and reduce total protein content in plants, which had close relationship with the senescence of plant .Meanwhile it was also a physiological performance of plant damage under drought stress [15]. As shown in **Figure 3(b)**, compared with the control group, 65 w ultrasonic processing of wheat seedlings increased protein content after 15 min, which could relieve plant senescence.

3.3. The Influence of 65 w, 15 min of Ultrasound Processing on the Relative Conductivity and MDA Content of Wheat Seedling under Drought Stress

Conductivity reflect the stand or fall of plant membrane system. When the plant was in stress or damage, membrane protein damage, membrane easily broke, even cytosol extravasation, which led to the increase of relative electrical conductivity [9]. So the relative electrical conductivity could be used as a physiological index of

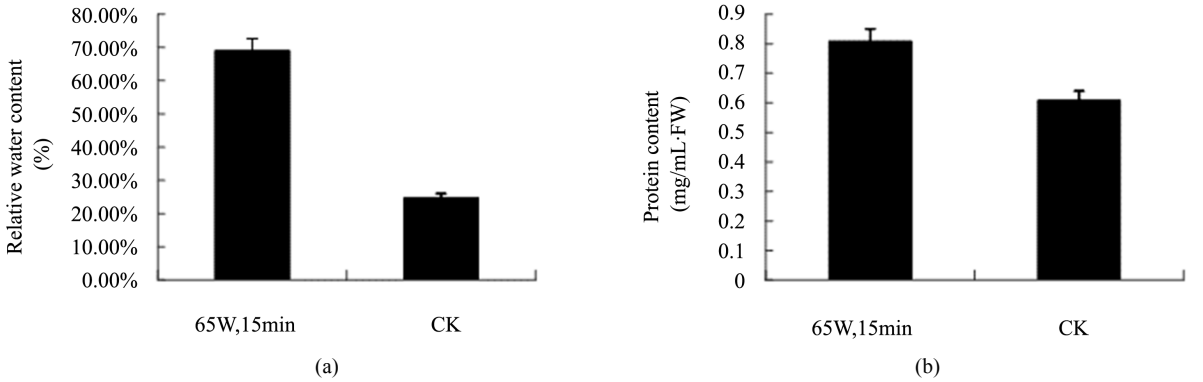

Figure 3. The Relative water content and Protein content of wheat seedling leaf.

membrane damaged. As shown in **Figure 4(a)**, the relative conductivity of the experimental group were lower than those of control group, which indicate membrane system was in good condition, but the effect was not very significant. Malondialdehyde (MDA) is one of membrane lipid peroxide .The generation of peroxide makes the membrane proteins in a state of permanent association, thus it can limit the movement of membrane protein. Increasing the MDA content is an important sign of membrane structure damage [16]. As shown in **Figure 4(a)**, MDA content in the experimental group was lower than control group, which showed that low doses of ultrasound could improve the wheat seedling cell membrane fluidity to a certain extent.

3.4. The Influence of 65 w, 15 min of Ultrasound Processing on SOD Activity and Amylase Activity of Wheat Seedling under Drought stress

Superoxide dismutase (SOD) containing metal ions is a kind of eliminable enzymes of active oxygen, which catalyze super oxygen anion disproportionation reaction, and generate H_2O_2 and O_2^-. Thereby, SOD can eliminate the damage of O_2^- to the cells [17]. As shown in **Figure 5(a)**, compared with the control group, wheat seedling of 65 w ultrasonic processing could increase SOD activity after 15 min, and effectively relieve the damage of super oxygen anion free radical that is produced by the drought stress to cells .Seeds store a lot of starch that can provide nutrients for the growth of embryo through the action of amylase catalyzing starch hydrolysis, when seeds germinate [18]. The amylase activity is a close relationship between seed germination and seedling growth. As shown in **Figure 5(b)**, amylase activity about 480 mg/g·min of wheat seed in the experimental group was higher than the control group, which showed that 65 w ultrasonic treatment is beneficial to seed germination and seedling growth of wheat after 15 min .

4. Discussion

Ultrasound as a form of stress role has important effects on plant growth and development [5]. Ultrasonic treatment can influence the growth of some organs of plant. Research found that a little of ultrasound could stimulate cell division, medium dose of ultrasound could restrain cell division, a large number of ultrasonic could cause cell death when ultrasonic process seeds. Study also found that spinach and cabbage seeds germination rate was increased with ultrasonic processing. Mild ultrasonic can make the plant root cell to vigorously divide, enhance plant growth ability, promote the plant to strike roots; which could decrease the respiration intensity of annual plants, while increase the respiration intensity of plants for two years.

Study found that a large number of ultrasound could restrain the growth of the plant, a small amount of ultrasound could improve the germination, growth of plants, root elongation, when treat wheat seeds with different doses of the ultrasonic .Study also found dealing plants with 65 w ultrasonic 15 min could work best.

Since water weight of saturation organization is stable, the change of the relative water content is more sensitive than the water content of fresh weight when the plant lacks water. Relative water content of plant can represent a kind of ability of holding water and avoiding dehydration, which can regard as a kind of index of plant drought resistance [7]. Protein content can reflect the degree of aging cell. If protein content is low, the cell's aging degree is serious. This study showed that wheat seedling leaf with 65 w ultrasonic treatment for 15

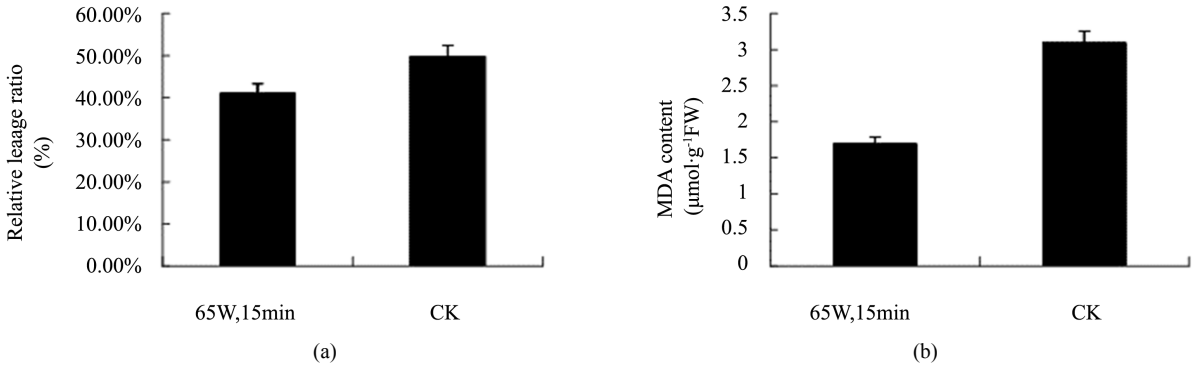

Figure 4. The relative conductivity Figure ure and MDA content of wheat seedling leaf.

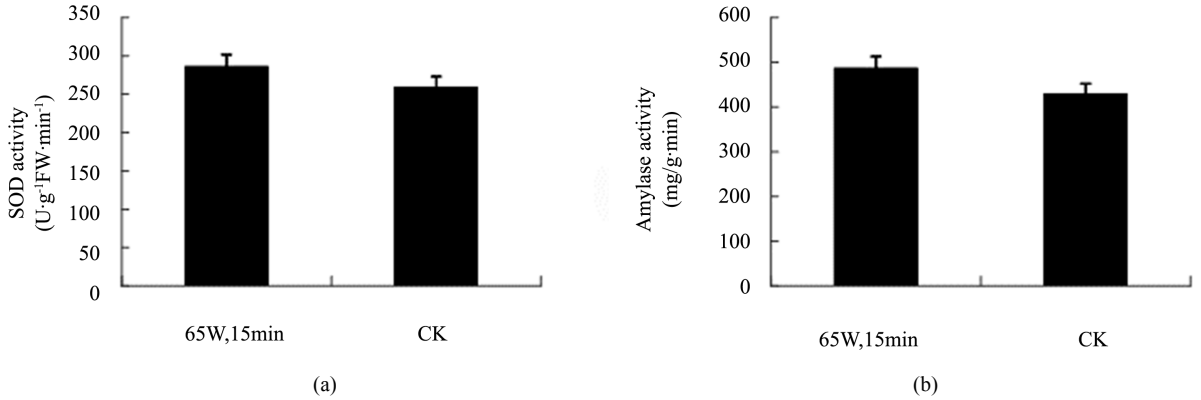

Figure 5. The SOD activity and amylase activity of wheat seedling leaf.

min relative water content and protein content were significantly higher than control group, which could demonstrate that low doses of and protein content, improve the ability of plant resistance to drought stress.

Plant in adversity, unsaturated fatty acid in the cell plasmalemma produce MDA through peroxidation, which may damage to the plasmalemma system and even may make the quantity of electrolyte inside the cytoplasm leakage increase. So MDA content can reflect one of the sign of damaging to membrane structure [16]. The permeability of plasmalemma can express the degree of membrane injury and degeneration. When the permeability of plasmalemma is big, the degree of membrane denatured is high [9]. This study showed that wheat seedling leaf of 65 w ultrasonic treatment for 15 min MDA content and relative conductivity significantly reduced than the control group, which Indicated that low doses of ultrasound could reduce blade MDA content and relative conductivity in different degrees to protect the plasmalemma structure from destruction. Thus Low doses of ultrasound could prove the ability of plant resistance to drought stress.

Protected enzyme that can elimate active oxygen system in plants is one of the important enzymes. The activity of SOD increasing is one of the behavior to cope with adversity stress. Amylase activity can reflect seed germination vigor. Wheat seedling with 65 w ultrasonic treatment for 15 min leaf SOD activity and amylase activity increased than the control group, which showed that low doses of ultrasound could increase the protective enzyme activity and amylase activity of wheat seedlings to effectively slow the damage of drought stress on wheat seedlings.

5. Conclusion

In this work, the wheat seedlings were treated by the ultrasonic. And then we measured the morphology and related physiological indexes of wheat seedlings, such as relative water content, relative electric conductivity, protein content, SOD activity and MDA content. And this research also studied the effects of ultrasonic on the drought resistance of wheat under drought stress. Our results showed that after ultrasonic treatment enhanced drought resistance of wheat seedlings, alleviate drought stress on wheat seedling injury to 65 w 15 min ultrason-

ic treatment works best.

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