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The effect of saline-alkali soil on romaine lettuce growth.

Yibo Shen

Shanghai united international school Qingpu campus, shanghai, China

Abstract:

The main purpose is to reveal the macroscopic effects of salt stress on oilseed rape, mainly the height effect of salt stress on oilseed rape, the effect of salt stress on the growth of oilseed rape roots, and the effect of salt stress on the overall weight of oilseed rape. In addition, there are also some explanations of the mechanisms by which the growth of oilseed rape is affected after being subjected to salt stress (relatively simple changes in chemical substance content, based on other papers), which do not include the data changes in chemical substance content in oilseed rape after being subjected to salt stress and the detailed pathways and methods by which oilseed rape responds to salt stress at the microscopic level.

Keywords: romaine lettuce, MDA, salt stress, length, weight, root length,

1. Introduction

The area of saline-alkali soil and alkaline land in the world is increasing every year, which has a big influence on crops yields [Ting, et al., 2014). Therefore, it is particularly important to find out the effects of salt stress on plants. At present, most of the research in this area is on some special (halophytes, such as Limonium bicolor) or more standard (referring to plants widely recognized worldwide, such as Arabidopsis thaliana). There are several reasons for this - first, standard plants can better reflect the effects of salt stress on plants, including the response of plants to salt stress (). Secondly, studying special plants such as halophytes or plants with high salt tolerance is a topic that is very relevant to real problems (improving saline-alkali land). But there are fewer studies other than this. In other words, other types of plants such as crops are not very popular (referring to less than the two directions mentioned above). Therefore, strengthening research in this area may better help solve the problem of saline-alkali land, at least to obtain the impact of saline-alkali land on the yield and growth of crops [Weiqiang, et al., 2022].

This experiment was inspired by 'Effects of Intercropping Halophytes on Potato Yield, Improvement of Saline -alkali Land and Economic Benefits' [Weiqiang, et al., 2022] was conducted. This experiment aimed to prove that intercropping halophytes has an important impact on saline-alkali land improvement and saline-alkali land crop yield. The hypothesis is that halophytes are helpful for saline-alkali land improvement and cultivation. At the same time, this experiment also aimed to provide theoretical basis and support for the effects of intercropping halophytes on lettuce, such as yield, weight and other aspects. Also, the influence of salt to the lettuces chemical content and it's exterior (color of leaves, shrink or not etc) can be discovered. However, limited by technique, time and other staff, this experiment is almost only about the macroscopic of salt stress on the romaine lettuce.

This experiment uses four-season lettuce seeds as experimental materials, and will be divided into three groups in total. There is a control group and two experimental groups, each with three boxes for planting. The two experimental groups will be regularly treated with 3g/L and 6g/L salt water respectively. Under expected conditions, the growth state of lettuce should be best without salt water treatment, followed by 3g/L and finally 6g/L. Also, after the crops mature (about 40-60 days), samples of the crops will be recorded its data (average root length, average length, average weight) .

This experiment is mainly research on the macroscopic influence of salt stress on romaine lettuce, so will not get much explain on the chemicals and change of gene in the lettuce.

2. Literature review

Romine lettuce, is a kind of crop which has a better ability on salt tolerance in the soil when compared with the other plants [Ting, et al., 2013]. Some experiments show that Romine lettuce gets a good ability on grow on the low concentration saline alkaline soil (75mmol/L) but the weight and water contact in will decrease (inversely proportional) to the concentration of salt contact in soil [Shuang, et al, 2023, Ting, et al, 2013]. It could normally grow in the Electrical conductivity (EC) value from 1.2ms/cm to 3.0ms/cm [Shuang, et al, 2023]. The reason can because some of the chemical's increase

Salt stress

The influence of salt stress usually depends on the concentration of salt in the land and PH level of the land. Normally these data are directly proportional to the concentration of salt and plant growth is inversely proportional to salt concentration. For example, romaine lettuce can't grow at or above 225mmol/L salt water, and it get a low level of chloroplast at 150mmol/L of salt water [Zhang, et al., 2014]. When this data (150mmol/L,50mmol/L, 25mmol/L) is used to draw a graph, can easily find out that plants' growth is inversely proportional to the concentration of salt [Zhang, et al., 2014].

Change chemicals

From the chemical, Romine lettuce will get higher vitamin C (directly proportional) when salt concentration in the soil increases, but dissolvable sugar and protein is decreasing (inversely proportional) to the salt concentration in the soil [Shuang, et al., 2015].

The increase of vitamin C in plants is usually considered a positive change. Vitamin C (ascorbic acid) plays an important role in plant health and growth. The main function and benefit of vitamin C in plants is Antioxidant protection. Vitamin C is a potent antioxidant that can protect plant cells from damage caused by free radicals and oxidative stress. This helps maintain the overall health of plants and improve their disease resistance. High levels of vitamin C can also enhance plants' tolerance to environmental stresses such as drought, high salinity, pests and diseases. It can help plants better cope with adversity by enhancing their antioxidant capacity [Liusheng H., et al, 2010].

Dissolvable sugar and protein's decreasing can help plants to defend against adversity stress and let it grow faster than before. Also, it can help plants to defend the disease [Chat-4o-mini, 2024].

Imitate environment

On the imitate environment of saline alkaline soil normally can use solution of NaCl to water the soil, so that soil will get salt inside and can start effecting salt stress to plants

[Shuang, et al., 2023].

Peroxidation

Membrane lipid and lipid peroxidation will normally happen when a plant is experiencing adversity. The final product of this process is malonaldehyde (MDA) and concentration of MDA in the plant will increase until the time when there is no membranous peroxidation is happening. That means MDA is a very good data to collect in order to analyse the influence of salt stress on plants [Bio-review,2018].

The peroxidation mechanism

Membrane lipid or lipid peroxidation is the result of the reaction of oxygen radicals with polyunsaturated fatty acids [Bio-review, 2018], see Figure1 and 2. Regardless of animals and plants, this process will be controlled very carefully, in order to not make mistakes, however when metabolism is abnormal or immune function is reduced (normally under an adversity stress), this balance will be destroyed. It will result in enhanced lipid peroxidation reactions, forming the final decomposition products, MDA and 4-hydroxynonenoic acid (HNE) [Bio-review, 2018, Ting Y, 2018].

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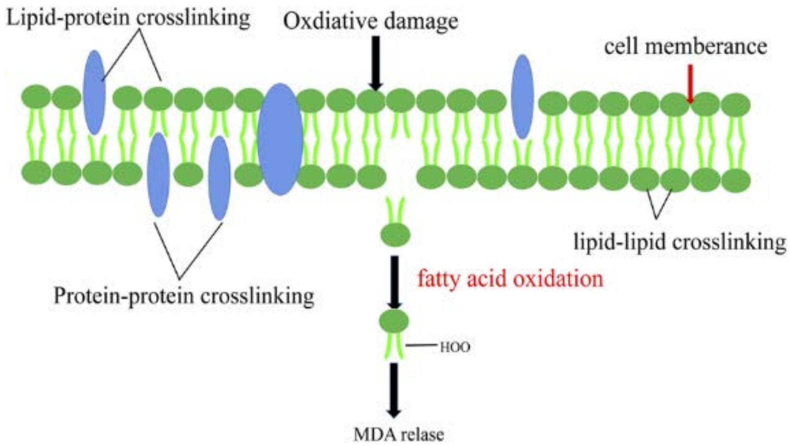

Figure 1 lipid peroxidation [Researchgate, 2022]

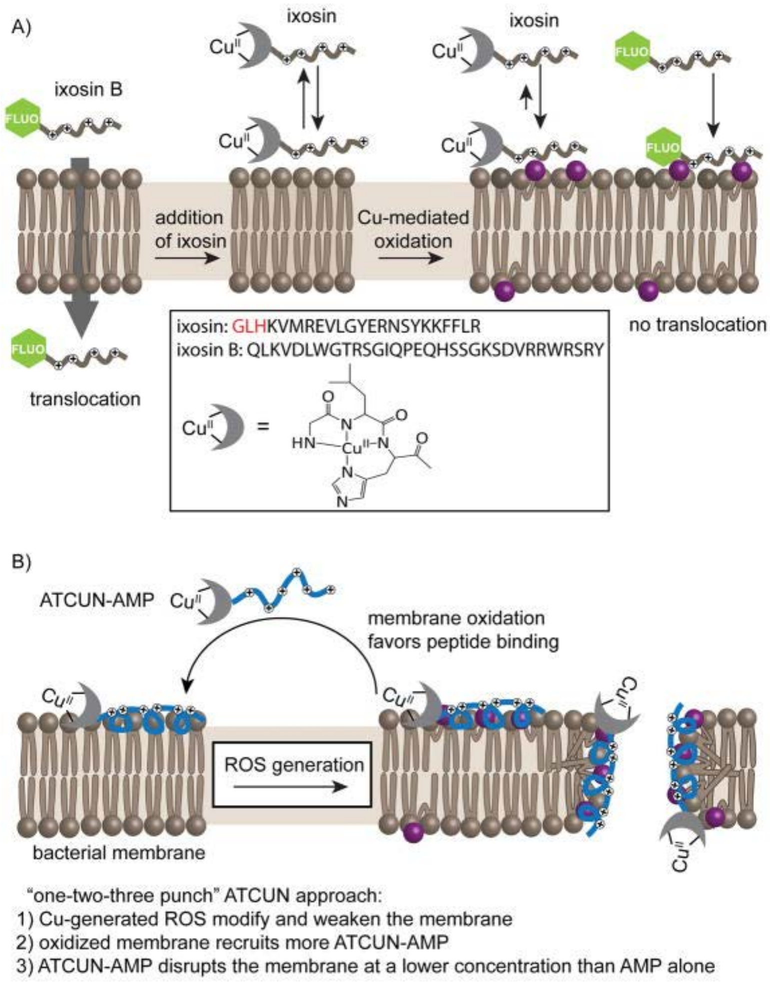

Figure 2 membrane lipid peroxidation [Researchgate,- 2022]

MDA

This is one of the final decomposition products of Membrane or lipid peroxidation. Its content can reflect the degree of damage suffered by plants under adverse conditions. After being released from the location where MDA is produced on the membrane figure3, it can react with proteins and nucleic acids, causing them to lose their functions. It can also relax the bridge bonds between cellulose molecules or inhibit protein synthesis. Also, MDA can produce oxygen radicals which can cause lipid peroxidation. Therefore, the accumulation of MDA may cause certain damage to membranes and cells.[Bio-review, 2018, Ting Y, 2018].

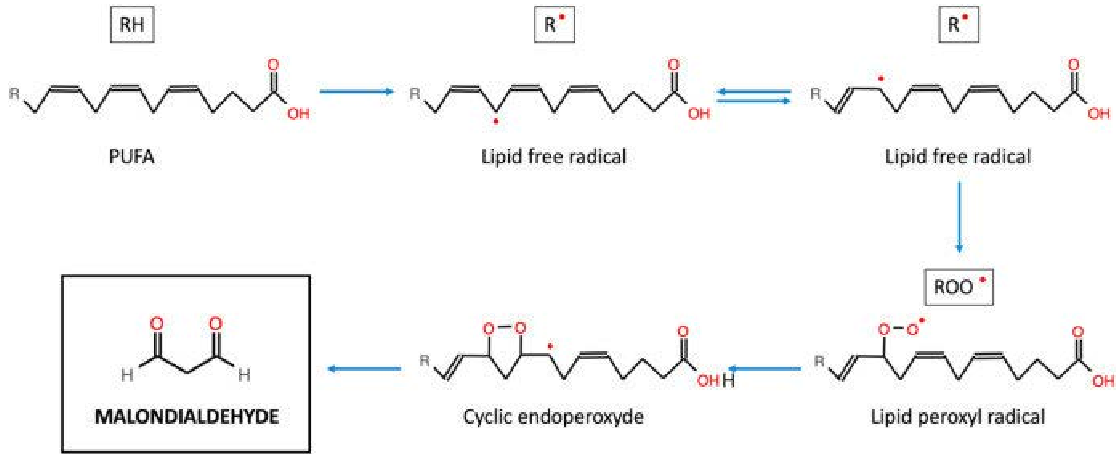

Figure 3 MDA[Researchgate, 2022]

EC value

Electrical Conductivity (EC) value is a physical quantity used to measure the ability of a solution to conduct electricity. It indicates the concentration and activity of ions or conductive substances in a solution. The EC value refers to the ability of a solution to conduct electric current. It is determined by the concentration of ions in the solution and their mobility. Unit: The standard unit of conductivity is Siemens (Siemens, S), but the most commonly used units in experiments are micro-Siemens (µS/cm) or millisiemens (mS/cm). EC value is measured by a conductivity meter, which has two electrodes. When current passes through the solution, the conductivity meter measures the relationship between current and voltage, thereby calculating the conductivity. The higher the ion concentration in the solution, the greater the conductivity value, because more ions can conduct electricity [Baidubaike, 2023, Chat-4o-mini, 2024].

3. Methodology

Overview

This dissertation uses both primary and secondary research. Secondary research was found using online data and literature for the purpose of information gathering. Primary research was conducted to use in the experiment, the purpose was to find out if the salt concentration of the soil had an effect on the growth of romaine lettuce.

Secondary research

The main uses of secondary research materials and literature are to provide experimental methods (imitate environment of saline alkaline soil), clear experimental direction (influence of salt stress to Lettuce), research on experimental principles (change of chemical in the lettuce, membrane lipid and lipid peroxidation) and provide background information (salt stress influence on lettuce). These sources information and data are mainly coming from 'Science direct' and 'Cnki'.

The main keywords of my search are 'salt stress, influence and lettuce' which means the articles have these words at a higher priority level. On the other hand, this research direction already has a large and relatively complete foundation, which means there will be a lot of appropriate data and basic theories to refer to. Due to this, there is not a very strict standard in the selection of articles, because the content of most articles is sufficient to meet the research needs.

Primary research

This experiment aims to find out the influence of salt stress on the growth of romaine lettuce (four season romaine lettuce) and seeds is from 'Cangzhou Jinke Lifeng Seed Co., Ltd'. There are three different groups in this experiment, the standard is the concentration of salt dissolved in the water which use to change the soil: 0g/l; 3g/l(experiment group); 6g/l(experiment group), and the same volume of water is used to water each group and experiment group will water by salt water which is as same as it's requirement (3g.l, 6g/l) . Then the seeds were evenly distributed in each experimental group and picked after the waiting period was completely mature. The influence of salt stress will be measured to using average weight of the lettuce and the average height of every group. Once the data is recorded it can be analysed.

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There are lot of variables which need to be controlled, such as temperature, water and light. Limited by technique and time, experimental variable control can only be done in the next best level option, conducting the experiment in the same environment. That means, some of the variables will influence the experiment a lot, so that the group which get too big influence will be excluded from the final statistics. Specific impact will be spoken at the discussion.

4. Results

Overview

From the experimental results, the salt content of the soil has a certain impact on the germination rate, growth rate and growth quality of rapeseed. At the same time, it is also related to the planting depth and seed quality.

In this experiment, the measured data are: the total weight of each group, the average weight per plant in each group, the average length per plant in each group and the average root length per plant in each group. Unfortunately, in this experiment, most of the chemical content in the plant could not be determined due to technical limitations (MDA, Vitamin C, Water, EC value).

Weight

Due to salt stress, the weight of plants decreases as the soil salt content increases. This is mainly due to the effect of salt content on the growth rate of plants and the water content in the plants figure4, 5, 6. From the data of total weight, the influence of soil salt content on the final yield of plants is great (it can not be ruled out that it is the problem of sowing methods). But in general, the growth of romaine lettuce is inversely proportional to the soil salt content. In other words, other plants should be the same, and the main reasons are probably the damage of cell structure caused by membrane lipid peroxidation and the decrease of photosynthetic efficiency caused by salt stress [Zhang T, 2014].

Figure 4 weight of 6g/l (43.3g)

Figure 5 weight of 3g/l (78.3g)

Figure 6 weight of 0g/l (241.0g)

Length

In terms of average length, the difference between 3g/l, 6g/l and 0g/l is not particularly significant. However, comparing 6g/l and 0g/l, the average length of the two sides is about 1.3 cm apart figure7. The reason may because the salt influences the transmission so that plant can't get enough nutrition to grow up fast. Interestingly, in each experimental group treated with saline water, the number of leaves was also affected by salt stress. And it seems to be related to plant height, with the specific manifestation being that the taller the plant, the fewer leaves it has (in each group, plants that grow taller (above average) generally only have 2-3 leaves, while those that grow shorter (below average) have the opportunity to grow more leaves, usually 3-4 leaves) Fig 8, 9, 10. This phenomenon was mostly observed in the experimental group at 3g/l, with a small amount at 6g/l (not significant, possibly due to the significant impact of high salt content on plants), and almost no observation was made at 0g/l.

Since this phenomenon was discovered during the height measurement phase after the experiment, further research has not been conducted yet. However, in collecting information, there are indeed articles and materials mentioning that salt stress may have an impact on the number of leaves in plants.

	0g/L	3g/L	6g/L
Group1	15.2cm	14.4cm	13.8cm
Group2	15.3cm	14.2cm	14.1cm
final	15.2cm	14.3cm	13.9cm

Figure 7 data of experiment(average length) (final is group1+group2 / 2)

Figure 8 length(13cm),4leaves group: 3g/l

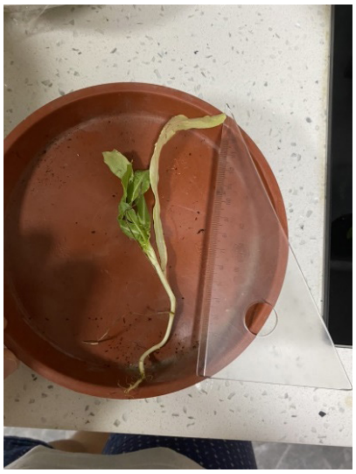

Figure 9 length(15cm), 2leaves group:3g/l

Figure 10 length(13.6cm), 3leaves group: 3g/l

Root length

Due to the relatively short roots of oilseed rape, most of them are distributed in shallow layers, so there was no significant difference after the experiment and measurement were completed. Most of them are around 4-5 centimeters, except for a few oilseed rape plants in the 0g/l control group with root lengths exceeding 5 centimeters, there is basically no difference in the rest Figure11, 12, 13. Therefore, the difference in average root length between them can be almost negligible.

It is worth noting that many plants planted in the experimental group treated with saline water and irrigated showed varying degrees of curvature in their main roots, while the fibrous roots grew more unevenly (focusing on the side where the main roots were curved). Based on the specificity of the group in which this phenomenon occurs (referring to the fact that it only occurs in the experimental group treated with salt), it can be considered that it is the impact of salt stress on it, rather than a problem with planting techniques or some other issues unrelated to salt.

In other words, it is likely that there are specific genes (promoters) or special enzymes inside these lettuce (also other plants) that allow them to recognize or avoid areas with high salt concentrations [Zhengwei Y et al, 2021]. This kind of strategy allows them to achieve better environmental adaptation (at least on saline soil). That means, lettuces' (also other plants) roots will respond to salt stress and make corresponding responses at the same time [Zhang, Y., e tal, 2024]. Research in this area has not been involved much with lettuce for the time being, but there are still other studies that can be used to address this fact.

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Figure 11 length(4.3cm) group: 3g/l

Figure 12 length(4cm) group6g/l

Figure 13 length(5cm) group: 0g/l

5. Summary of result

The aim of this experiment is to investigate the macroscopic effects of salt stress on lettuce, with a focus on the changes in plant weight, height, and root length under different salt concentrations. The results showed a clear trend of the impact of salt stress on these parameters, but due to technical limitations, more detailed biochemical data (chemical content) and potential mechanisms have not been studied.

The effect of salt stress on plant weight

The most significant effect of salt stress on plant weight was observed. The data shows a significant negative correlation between salt concentration and the total weight of lettuce plants. As the salt concentration increased from 0g/L to 6g/L, the plant weight significantly decreased. This reduction may be attributed to the disruption of cellular function and osmotic balance caused by high salinity. Salt stress can affect water absorption, reduce nutrient availability, and alter metabolic processes, leading to growth retardation and biomass reduction. This finding is consistent with previous studies, indicating that high salinity has adverse effects on plant growth and yield due to its impact on cell integrity and function [Zhang et al., 2014].

Root length and morphology

Regarding root length, the experiment did not show significant differences between the salt treatment groups, with most root lengths ranging from 4-5 centimeters. However, it is worth noting that the main roots of the salt treated group showed bending phenomenon at higher salt concentrations. This morphological change indicates that salt stress triggers adaptive responses in root development. Plants may alter the growth pattern of their roots to reduce exposure to high salt concentrations, thereby increasing their chances of survival. These reactions are consistent with other studies on plant adaptation to saline alkali conditions [Zhang Y. et al., 2024].

Plant height and number of leaves

The impact of salt stress on plant height is relatively mild. Although the height of the salt treatment group slightly decreased, there was no statistically significant difference compared to the control group. This indicates that salt stress may have a greater impact on growth indicators such as weight than on height. In addition, an interesting trend was observed in the number of leaves. In the 3g/L salt treatment group, tall plants typically have fewer leaves, indicating a potential trade-off between height and leaf development in plants under salt stress. This observation suggests that plants may reallocate resources under stress, focusing more on growth rather than leaf development. However, further research is needed to fully understand its significance.

6. Discussion:

This part will discuss some phenomenon in the experiment and also give out some suggestions about the reason of it.

Impact of Salt Stress on Plant Weight

The most significant effect was on plant weight, which decreased significantly with increasing salt concentrations. This finding is consistent with existing literature, which generally shows that high salinity has a negative impact on plant growth and yield. The weight reduction can be attributed to multiple factors, including impaired cellular function and osmotic imbalance due to increased salt levels. High soil salinity can also affect plant water absorption and nutrient uptake, leading to reduced biomass accumulation. The results demonstrate the importance of soil salinity in affecting crop productivity, especially in regions facing increasing salinization.

If we want to solve with this problem, we can generally plant a large number of plants and select the plants with better growth and then cultivate them further. However, on the other hand, it may be possible to use certain salt stress to develop or direct the cultivation of new plants, which are expected to be small and salt-tolerant.

Root Length

Although there were no significant differences in average root length between the different salt treatments, a clear morphological change, namely the bending of the taproot, was observed in the high salt concentration group. This adaptive change suggests that lettuce plants change their root growth pattern in response to salt stress, possibly to reduce exposure to salinity conditions [Zhang, Y., et al. 2024].

This reaction can be used in many aspects, such as precision agriculture and plant removal. In precision agriculture, plants can be used to distinguish between high-salinity and low-salinity areas and change the growth morphology of their roots according to the salt concentration. Generally, they grow towards low-salinity concentration. In this way, the growth morphology of plant roots can be used to confirm the salt concentration of different parts of the land, which can greatly improve the efficiency and yield of crops planted on saline-alkali land. On the other hand, this can also greatly improve the efficiency of improving saline-alkali land (better confirmation of priority). In plant removal, salt water can be used to irrigate the growth areas of weeds or invasive plants to inhibit the further expansion of the growth range of these plants, weaken these plants, and finally cooperate with other plants to gradually remove them to achieve the purpose of land management. Compared with physical methods (burning, manual pulling) that may not completely remove these plants and chemical methods (spraying toxic potions) that will greatly damage the land, this removal method reduces the damage to the land a lot, and finally only needs to be watered with a large amount of clean water to recover [Jing, W., et al. 2023, Jian, Y., et al. 2013].

Plant Height and Leaf Numbers

The effect of salt stress on plant height was relatively small, but an interesting trend was observed in the 3 g/L salt treatment: taller plants had fewer leaves. This suggests that under salt stress, plants may experience a trade-off between height and leaf development, possibly due to strategies adopted by plants in terms of resource allocation.

This observation provides new ideas for studying how to optimize plant growth parameters under salt stress. For example, we can study the relationship between the number and height of leaves of plants under salt stress to find the mechanism behind this trade-off. Then we can conduct more in-depth research to obtain the changes in various internal indicators (mainly the content of chemical substances) after the plant makes this trade-off, and then we can start from this aspect to carry out targeted transformation and cultivation of plants. In general, understanding this trade-off can have a profound impact on agriculture and have the opportunity to improve various characteristics of plants to achieve certain special purposes. On the other hand, it can be used in the management of invasive plants. The characteristic of having fewer leaves under certain salt stress can be used to affect the offspring of plants, causing the efficiency of photosynthesis to decrease. This will reduce the racial advantage of plants, so that local plants can better inhibit their growth, and finally achieve better control of invasive plants (narrowing their growth range and controlling them in a specific area).

Improve of experiment

Although this experiment provides valuable macroscopic data on the effects of salt stress on romaine lettuce, the experimental design and methods can be further improved to gain a more comprehensive understanding of the effects of salt stress on plants. First, the current experiment mainly relies on macroscopic observations, such as plant weight,

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height, and root length. In order to obtain more detailed physiological and biochemical data, it is recommended to introduce detailed biochemical analysis in future studies. For example, measuring the levels of endogenous plant chemicals, such as propylene glycol (MDA) and the concentration of antioxidants such as vitamin C, can provide more information about how plants respond to salt stress. As a marker of lipid peroxidation, propylene glycol (MDA) can reflect the degree of damage to the cell membrane, while vitamin C plays a key role in resisting oxidative stress [Huaming, A., et al. 2004]. These biochemical indicators help reveal the effects of salt stress on plant cell structure and function, thereby supplementing the lack of macroscopic data.

In addition, long-term observations of plant growth under different salt concentrations should be added to the experiment to obtain more comprehensive data. Although short-term experiments can show the initial effects of salt stress, long-term data can help reveal the adaptation mechanism of plants under continuous salt stress and its changing trends. For example, the experimental period can be extended to monitor plant growth, development and yield changes to better understand the long-term effects of salt stress on plants. At the same time, repeated experiments can be carried out under more different salt concentrations to ensure the reliability and repeatability of the data.

More over, to better simulate the actual agricultural environment, the effects of different soil types and environmental factors (temperature, humidity, light intensity) on salt stress can also be considered in the experimental design. Different soil types and environmental conditions may affect the distribution of salt and the coping strategies of plants. Therefore, the general applicability of research results can be improved by diversifying experimental conditions. In addition, combined with molecular biology techniques, such as gene expression analysis, the gene regulation mechanism of plants under salt stress can be revealed, providing guidance for future genetic improvement and salt tolerance research.

Through these improvements, the effects of salt stress on romaine lettuce can be more fully understood, and more scientific solutions can be provided for dealing with salinization problems.

Future

This study contributes to understanding the macroscopic effects of salt stress on lettuce, but also highlights the necessity for further research on the microscopic and biochemical changes of plants under salt conditions. Although experiments focus on observable features such as plant weight, height, and root length, future research should delve deeper into the chemical and physiological responses of lettuce under salt stress. However, macroscopic studies are still important because they can better illustrate the effects of microscopic changes. At the microscale level, changes in endogenous chemicals such as propylene glycol (MDA), a marker of lipid peroxidation, and the role of vitamin C in coping with stress may be mainstream.

From another perspective, studying the visible effects of salt stress on plants can also make certain contributions to other fields. Just like the examples in the previous article (plant management, saline-alkali land cultivation, saline-alkali land improvement, plant improvement). Therefore, it can be seen that in future research, multidisciplinary cooperation will become the mainstream. This means that disciplinary research will no longer be synonymous with a single field, but will gradually turn to cooperation or multidisciplinary research. Similarly, in the application of various fields, multi-field cooperation will also be the mainstream. This means that the future will be an age of win-win cooperation.

7. Evaluation

Limitations

Considering that during the research process, quantitative and qualitative analysis of chemical substances (such as MDA, vitamin C, sugar, etc.) in plants was not possible due to factors such as equipment, technology, and time, this article can only prove that oilseed rape is affected by salt stress, leading to growth problems (root development, number of plant leaves, germination rate, etc.). But it cannot reveal the underlying mechanism.

On the other hand, this article was conducted outdoors during summer, and although every effort has been made to control variables, it cannot be ruled out that some uncontrollable external factors may affect the experimental results (such as diseases, high temperatures, heavy rain, etc.). Therefore, this article cannot rule out the possibility of anomalies and impacts caused by external force majeure factors.

What's more, the salt concentration and treatment conditions used in the experiment are limited. The salt concentration and environment in the actual agricultural environment vary greatly, and the soil conditions vary greatly. A single salt concentration treatment may not be able to fully simulate the actual salt stress situation. The effects of different soil types and environmental factors on salt may also lead to different plant responses. Therefore, the singleness of the experimental conditions limits the general applicability of the research results.

Furthermore, this experiment failed to consider the impact of plant genomic differences on salt stress. Different lettuce varieties or genetic variations may lead to different salt tolerance, and these differences may affect the experimental results. Combining genomics or molecular biology techniques can further explore the genetic regulatory mechanism under salt stress and provide important information for understanding the salt tolerance of different varieties.

Success

This experiment successfully revealed the macroscopic effects of salt stress on rapeseed by systematically studying the effects of different salt concentrations on rapeseed growth. The experimental design included a control group and two experimental groups, which were treated with 0g/L, 3g/L and 6g/L salt water, respectively, to observe indicators such as the growth status, root development and overall weight of rapeseed. Such a design makes the experimental results highly comparable and reliable, and can effectively demonstrate the effects of salt stress on rapeseed growth. In addition, the experiment also considered variables such as temperature, moisture and light. Although the degree of control was insufficient due to technical and time constraints, it was still able to provide valuable preliminary data. This design not only provides a basis for subsequent research, but also provides a reference for the improvement of saline-alkali land in agricultural practice.

The experimental results show that the increase in salt concentration has a significant negative impact on the growth of romaine lettuce, especially in terms of plant weight and growth rate. By measuring the weight, length and root length of romaine lettuce under different salt concentrations, the experiment successfully demonstrated the trend of the effects of salt stress on plants. In addition, the experiment also observed that the roots of plants in the salt treatment group were bent, which indicates that plants may adjust their root growth pattern under salt stress to reduce exposure to high-salt environments. This comprehensive analysis of the data not only provides a scientific basis for understanding the impact of salt stress on rapeseed growth, but also provides new ideas for future research.

8. Conclusion

From the current perspective, the macroscopic effects of salt stress on plants (referring to the impact on plant appearance, height, and changes in appearance) are relatively limited. Most research focuses on the microscopic effects of salt stress on plants, referring to changes in the internal chemical content of plants when subjected to salt stress, changes in the number and function of various promoters in plants when subjected to salt stress (coping mechanisms) and changes in the substances released by plants to the outside world. Therefore, future research on the macroscopic effects of salt stress on plants may be a research direction.

This study investigated the macroscopic effects of saline-alkali soils on the growth of romaine lettuce, focusing on key parameters such as plant weight, height, and root length under different salt concentrations. The widespread increase in saline-alkali soils around the world poses a major challenge to agricultural productivity, so understanding crop responses to salt stress is very important. This study contributes to this understanding by systematically analyzing the growth response of romaine lettuce to different salt treatments.

Three groups of romaine lettuce were used in the experiment, one of which was a control group without salt treatment; the other two groups were treated with 3g/L and 6g/L saline, respectively. The results showed a clear negative correlation between salt concentration and plant weight, and high salt concentrations significantly reduced the overall biomass of romaine lettuce. This decrease in weight was attributed to the disruption of cell function and osmotic balance, which also indicates that nutrient absorption and water uptake are crucial. This finding is consistent with existing literature on the negative effects of high salinity on plant growth and yield.

Although the experiment did not show significant differences in mean root length between treatment groups, some morphological changes were observed, especially the bending of the taproot under high salt concentrations. This adaptive response suggests that romaine lettuce may adjust its root growth pattern to mitigate exposure to saline-alkali conditions, thereby improving its chances of survival. The study also noted an interesting trend in that plants in the 3g/L treatment group were taller but had fewer leaves, suggesting that there may be a trade-off between vertical growth and leaf development in plants under salt stress.

Despite valuable insights gained, the study also had some limitations, such as the failure to analyze biochemical parameters such as malondialdehyde (MDA) and vitamin C due to technical limitations. These factors are critical to understand the cellular mechanisms of salt stress response. Future studies should include biochemical analysis and long-term observations to provide a more comprehensive understanding of the adaptation of romaine lettuce or other plants to saline-alkali conditions.

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In conclusion, this study highlights the significant effects of saline-alkali soil on the growth of romaine lettuce, and the need for further research on the biochemical and physiological responses of crops to salt stress.

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