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Effect of Drought Stress at Growth and Development of Pea (*Pisum sativum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

One of the most important environmental factors that can has the significant effects on growth and development of the plant is drought stress. Drought condition causes the plant to undergo several physiological and biochemical changes that may have an impact on how well it functions overall. Peas belongs to a family Leguminosae which is cultivated as an edible seed all over the world which have the high nutritional importance. They are an effective source of fiber, vitamins, minerals, and plant-based protein. Legumes are essential for crop rotation because they fix nitrogen in the soil, enhancing soil fertility and lowering the demand for artificial fertilizers. Around 9,000 years ago, this crop has been cultivated in the Near East and the Mediterranean region. By altering numerous

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physiological and biochemical processes, including photosynthesis, water uptake, and nutrient assimilation, drought stress can drastically lower the productivity of this crop due to the numerous alterations of physiological and biochemical process such as photosynthesis, water absorption ratio and nutrients uptakes. Lack of water can cause pea plants to grow slowly, have fewer leaves, and causes the crop production decline. Drought stress not only affects growth and photosynthesis but also has the potential to affect the reproductive development of plants. Not only can drought stress cause fewer flowers to be formed, but it can also cause the size and weight of the seeds to diminish. Additionally, it might lead to a decline in pea quality and production. Pea plants have a number of defense mechanisms to deal with drought stress, such as altered root systems, osmotic adjustment, the synthesis of antioxidants, and stomatal modulation. The activation of genes that control the synthesis of osmo-protectants, including proline and sugars, as well as the expression of stress-responsive proteins, like LEA proteins and chaperones, is part of the molecular defense system against drought. by understanding the effect of drought stress and its mechanism activated under the stress condition to tolerate this stress.

Keywords: Drought; photosynthesis; osmotic adjustment; antioxidant.

1. INTRODUCTION

The growth and development of plants can be influenced by a variety of environmental conditions, including soil quality, temperature, light, water and nutrients which are climate variables that can have significant effects on plant physiology and define the kinds of plants that can flourish in a specific area. Especially, water deficiency and flooding cause the huge reduction in the productivity of crop [1]. Natural disasters including drought may seriously hamper the agricultural growth and productivity, which in turn can have an impact on food security. Different types of crops may respond differently to drought depending on its intensity and length but in general, drought can result in decreased photosynthesis, water and nutrient intake and plant development. Plant development and survival may be hampered by drought stress or waterlogging caused by insufficient or excessive precipitation, respectively [2]. A long period of particularly limited rainfall defines a drought as a natural calamity, which causes a lack of water supplies. Crop failure, livestock deaths and a lack of water are all possible consequences for agriculture, wildlife, and human populations. Also, droughts can worsen other environmental issues like wildfires, soil erosion, and desertification. Droughts are predicted to become more frequent and severe in many parts of the world due to climate change, creating a serious worldwide challenge that calls for proactive management and adaptation solutions [3]. Pea is a leguminous crop that is frequently consumed and has a number of health and environmental advantages. Pea cultivation has been practiced for a very long time; pea domestication artifacts have been discovered at ancient Egyptian, Greek, and Roman archaeological sites [4]. During the middle ages, peas were widely grown in Europe and European settlers transported them to the Americas. Peas are an effective source of nutrients such as vitamins, nutritional fibers and minerals. They are a good source of vitamins B, C and K. Iron, magnesium, and potassium are among the crucial minerals that are present in peas. They are also an excellent source of plant_ based protein [5]. Peas have a number of health advantages. The high fiber content aids in controlling digestion and might aid in weight management. Flavonoids and carotenoids, two types of antioxidants found in peas, help lower the chance of developing chronic diseases like heart disease and some types of cancer. Peas are also anti allergic, which benefits general health [6]. Peas are adaptable and can be used in a variety of delicious meals and can used as dried, frozen, or fresh. Peas are often served as a side dish, in soups, stews, salads, and stir-fries. To prepare spreads or dips, they can also be crushed or pureed [7]. Peas have a long tradition of production and consumption across numerous cultures. They are a common ingredient in many cuisines and are frequently used in traditional foods and celebrations [8,9]. Because they can fix nitrogen in the soil, peas are said to be environmentally benign. Fixing nitrogen increases soil fertility and lessens the demand for chemical fertilizers. Peas are a sustainable option because they require less water to grow than other crops [10].

2. RESPONSE OF PLANT UNDER OSMOTIC STRESS

Drought has adverse effect at the growth and development of peas. Water must be available continuously for peas to grow and develop properly. The development and productivity of pea crops can be significantly impacted when there is a water shortage as a result of a dry soil during drought conditions can prevent plant roots from absorbing as much nutrients [11]. This may result in a decline in the plant's intrinsic health and vigor, stunted development, and decreased yields. Additionally, pea plants may become more vulnerable to pests and diseases as a result of drought stress. The amount of humidity has an impact on how quickly plants lose water through transpiration. Low humidity can cause an increase in water loss, whereas high humidity can reduce it. Some plants are adapted to specific amounts of humidity and may have difficulty surviving in areas with high humidity levels [12].

Pea germination and production can be significantly influenced by drought stress. Pea seeds need enough moisture to germinate, and protracted droughts might stop or postpone this process. In addition, drought stress may result in poorer seedling development, lower plant biomass, and reduced yields [13]. Through a variety of physiological pathways, drought stress can dramatically impair pea germination. One of the main reasons is the decrease in water availability, which can result in an increase in the pressure of water, which can harm the cell membrane and cause dehydration [14]. As a result, the seed may not absorb water at the same pace, which is crucial for germination. Inhibiting the enzymes that degrade the seed's stored food stores is another way. Amylase, a key enzyme in turning stored starch into sugars that give energy for germination, can become less active under drought stress. This may cause partial or delayed germination [15].

Moreover, the control of hormones in the seed, especially abscisic acid (ABA), might be impacted by drought stress. A hormone called ABA is essential for controlling seed germination and dormancy. Increased ABA levels under drought stress conditions cause an increase in seed dormancy and a decrease in germination rate [16]. The physiological and biochemical mechanisms of pea plants are susceptible to drought stress. For instance, drought stress can result in higher amounts of reactive oxygen species (ROS) and lower levels of antioxidants, which can harm plant cells through oxidative processes and adversely affect growth and yield [17,18].

The amount of chlorophyll in pea leaves can be significantly impacted by drought. The green color of plant is due to the presence of Chlorophyll and is essential to photosynthesis, the process through which plants turn sunlight into energy. Plants endure water stress during a drought, which may result in less water being available in the soil. As a result, plants reduce the intake of carbon dioxide (CO_2) required for photosynthesis by closing their stomata (tiny pores on the surface of the leaf). Due to this restriction, there is less CO_2 accessible for the photosynthetic process, which results in less glucose and other organic molecules being produced [19,20].

Plants may see a drop in chlorophyll concentration along with decreased photosynthesis. The molecules of chlorophyll are vulnerable to environmental stresses, such as drought. The breakdown of chlorophyll molecules or the reduced production of new chlorophyll can both contribute to the decrease in chlorophyll content [21].

3. DEFENSIVE MECHANISM UNDER DROUGHT STRESS

Drought stress can have a substantial effect on the process of photosynthesis. Reduced water availability for plants during drought circumstances impairs their capacity to absorb moisture through the roots and transfer it to the leaves. In order to prevent excessive water loss, the stomata on the surface of the leaf close, which reduces carbon dioxide (CO_2) uptake and restricts photosynthesis [22]. Pea plants can close their stomata to limit water loss, produce osmo-protectants to maintain cellular turgor, and activate stress-responsive genes to control physiological processes as some of their defenses against drought. Pea plants have evolved a number of chemical defenses against drought stress. The activation of genes that are responsive to stress and control the synthesis of proteins involved in stress tolerance is one such mechanism. These proteins support the preservation of photosynthetic machinery, cellular homeostasis, and defense against oxidative damage [23].

Aside from that, drought stress causes the synthesis of signaling molecules like abscisic acid (ABA), which is essential for controlling how plants react to water constraint. Stomatal closure, water conservation, and decreased transpiration rates are all benefits of ABA. Furthermore, it regulates gene expression to encourage the production of defense-related proteins and enzymes that increase drought resistance in plants [24]. Additionally, pea plants activate their antioxidant defense mechanisms to combat the rise in reactive oxygen species (ROS) brought on by drought stress. Chloroplasts, which are involved in photosynthesis, are among the biological components that ROS can harm. Superoxide dismutase (SOD) and catalase (CAT), two antioxidant enzymes, aid in scavenging ROS and shielding the photosynthetic machinery [25,26].

Generally, multiple molecular mechanisms, including gene regulation, ABA signaling, and activation of antioxidant defense systems, are involved in the response of pea plants to drought stress [27]. All of these systems work together to maintain plant survival during drought circumstances and to lessen the harmful impacts of water scarcity on photosynthesis. One of the strategies that helps the plant survive in a water-scarce environment is the activation of stress-responsive genes. These genes are in charge of making the proteins that shield the plant from harm brought on by water stress.

The DREB1 gene is one of the most significant stress-responsive genes in pea plants. This gene creates a protein that aids in controlling how the plant reacts to drought stress. The DREB1 protein activates additional genes that aid the plant in water conservation and cell protection when it is subjected to drought conditions [28]. another mechanism is LEA gene, a crucial stress-responsive gene in pea plants. This gene results in the production of a protein that aids in preventing dehydration-related cell damage in plants. By stabilizing other proteins and preventing their unfolding and destruction, the LEA protein serves as a molecular chaperone [29].

4. CONCLUSION

The activation of genes that control the synthesis of osmo-protectants, including proline and sugars, as well as the expression of stress-responsive proteins, like LEA proteins and chaperones, is part of the molecular defense system against drought. by understanding the effect of drought stress and its mechanism activated under the stress condition to tolerate this stress.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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