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The Influence of Abiotic Factors on Plant Growth and Development

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Abstract. *The habitat is the part of nature in which an organism lives. Living organisms are inextricably linked to their environment; they influence each other in a wide variety of ways. Environmental components that influence an organism are called environmental factors, or ecological factors. Inanimate factors, or physical factors (abiotic factors), include light, humidity, heat, wind, rain, hail, and the salt and gas composition of soil and water—to name just a few. Environmental factors are extremely diverse. The responses of living organisms to their influence are equally diverse. Light is a crucial factor for most plants and animals. Light is one of the most important abiotic factors, especially for photosynthetic green plants. Photosynthesis, the most important process in the biosphere, occurs only in the presence of light. Light influences the rate of plant growth and development and the intensity of photosynthesis.*

Keywords: *plant, growth, water, soil, light*

Introduction

Let's imagine there were no plants left in the world. What would happen then? The fact that it would be unsightly is only half the problem. But the fact that we couldn't live without plants is truly a disaster. After all, plants have a very important secret. Amazing transformations occur in plant leaves. Water, sunlight, and carbon dioxide—the gas we exhale—are converted into oxygen and organic matter. Oxygen is necessary for us and all living things to breathe, and organic matter for nutrition. So, one could say that plants contain a veritable chemical laboratory for the production of vital substances (Artamonov, 1991).

Plants are used by humans not only as a source of food but also as raw materials for various industries: food, textile, paper, chemical, and others. Since the importance of plants for human life is so essential, it is crucial that crop yields be consistently high. Taking into account all of the above and having defined the current research problem, we wanted to analyze how external conditions (light, heat, moisture, and air) influence plant growth and development, and, consequently, yield increases. The objects of the study were bean seeds and sprouts, potato tubers, and onion bulbs. The subject of the study was the influence of external conditions on plant growth and development. We set ourselves the goal of studying the conditions for plant germination and development using onions, potatoes, and beans as examples (Baturitskaya, 1991).

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To achieve this goal, we set the following objectives:
1. To practically identify the influence of external conditions (lack of light, moisture, and air) on seed germination and plant growth.
2. To study information on the influence of external conditions on plant growth from literary sources.
3. To analyze the results and draw conclusions.
Light has a profound effect on plants. Without sunlight, no plant can survive; it is essential for normal development. Under the influence of light, various chemical reactions called photosynthesis occur in the leaves. During this process, the plant absorbs carbon dioxide and water from the air and returns oxygen (Zanina, 2005, p. 64). This carbon dioxide allows the plant to form new tissue. Without photosynthesis, plant growth is impossible. Furthermore, light is needed to generate energy (Ivanov, 2001, p. 144)

Some plants adapt very quickly to low light. However, symptoms indicating a lack of light still appear. When a plant lacks light, growth slows. Leaves stretch upward and stems elongate. The distance between shoots and leaves increases, and the stem becomes thinner (Lebedev, 1988). If new leaves appear, they are much smaller than they should be. Lower leaves turn yellow and die. But the worst thing is that the plant will bloom little, the flowers will be paler, and the buds will develop poorly and fall off (Medvedev, 2004).

Methods

We decided to test how the presence of water affects bean seed germination. We took three containers, placed several bean seeds in them, and filled them with varying amounts of water. In the first container, the seeds were left without water, in the second, we placed a damp bandage and wrapped the seeds in it, and in the third, the bean seeds were completely covered with water. We observed the seeds daily. In the first container, which contained no liquid, the beans remained unaffected. In the second container, the bean seeds began to germinate on the second day. In the third container, filled with the largest amount of water, the beans failed to germinate; on the fourth day, an unpleasant odor developed, and the water became cloudy. The seeds in the second container continued to grow (Maksimov, 1966).

Thus, we can conclude that plants require water for germination, but only in a specific quantity. After confirming that plants require water, we decided to find out what kind of water is suitable for them. To do this, we conducted a second experiment. We took two jars, lined the bottoms with cotton wool, and planted onion bulbs in them. We watered one bulb with tap water, and the other with melted snow (Polevoy, 1989). After a week, we saw that the bulb planted in the jar with melted snow showed more vigorous root and leaf growth, as this water was natural and contained the necessary nutrients for growth. The tap water was likely chlorinated, which is why the bulb sprouted less well (Reinhold, 1987).

The Effect of Light on the Growth and Development of Bean Sprouts

Light is another crucial abiotic requirement for plant life. It is necessary for photosynthesis. If there is too little light, the plant is doomed to die, as the chlorophyll will rapidly degrade, leading to yellowing of the leaves and further deterioration of the plant itself. If natural light is insufficient, artificial light can be substituted (Tompkins, 2006).

We decided to conduct an experiment. Sprouted bean seeds were planted in two cups. We placed one cup in a dark place (a cabinet), and the other on a windowsill, and observed the results. Changes were noticeable after three days. The plants in the dark place developed poorly, while those receiving sufficient light grew strong, with large, green leaves.

We can conclude: when a plant lacks light, growth slows, the leaves stretch upward, and the petioles elongate. The distance between the shoots and leaves increases, and the stem becomes thinner. If new leaves appear, they are much smaller than they should be. The lower leaves turn yellow and die. The next important abiotic factor is air. Air plays a vital role in plant life. Oxygen is vital for all living things. Plants cannot germinate without oxygen (Tretyakov, 1990, p. 271). Roots, leaves, and stems all require this element. Is it true that plants need air? For our experiment, we took two flasks and half-filled them with water. We placed bean sprouts in them. One flask was left untouched, while sunflower oil was added to the other flask on top of the water. The beans in the flask with oil began to wilt after five days. This occurred because a film formed on the surface of the water, blocking oxygen from reaching the roots. The beans in the water without oil received oxygen and therefore remained alive and continued to grow. Studying Tropisms in Different Plants. We noticed that plants can move individual body parts throughout their lives. For example, houseplants turn their leaves toward the light. In science, such movements are called tropisms. Tropisms are cell orientation responses, that is, the direction of cell growth or movement relative to a stimulus. We decided to study tropisms such as geotropism, hydrotropism, and phototropism (Appendix 5).

Experiment 1. Geotropism

We took containers and filled them with soil. We planted sprouted bean seeds: one with the root facing up, the second with the root facing down, and the third with the root facing horizontally. All three roots grew downward, and all the stems grew upward. Conclusion: This means that the root exhibits positive geotropism, and the stem exhibits positive phototropism.

However, it can be seen that plants developing from seeds whose roots initially faced down and the stem upward grew and developed faster. The seedlings whose roots faced up did not sprout immediately; their growth was slow and they did not look as healthy as the previous ones.

Experiment 2. Phototropism

A potato tuber was placed in a maze (a shoebox with a hole on one side and partitions inside). After a month, the potato stems could be observed reaching toward the light and navigating around the maze's obstacles.

Experiment 3. Hydrotropism

Sprouted bean seeds were placed along the edges of a saucer using plasticine. Water was poured inside, and observation was made. After three days, the roots began growing toward the water. This demonstrated that the root also exhibits positive hydrotropism.

Findings and Discussion

The results of the first experiment showed that water is essential for plants from the moment a seed germinates and throughout its lifespan. Meltwater from snow and tap water have different effects on plant growth and development. Meltwater is absorbed by plants faster than tap water, and plants develop more rapidly. The second experiment demonstrates that plant growth is directly dependent on sunlight. The less light a plant receives, the less it grows. Plants follow the light, and leaves reach toward the light source.

The third experiment clearly demonstrates that plants require air for normal growth. If plant roots do not receive sufficient air, the plant becomes ill and cannot develop normally. The experiment also revealed the ability of plant parts to grow in a specific direction. These phenomena are called tropisms. For example, the plant root exhibits geotropism (regardless of the seedling's position in space, the main root always bends downward), while the stem exhibits phototropism (it reaches toward the light). Cell growth by elongation occurs intensively in the dark, resulting in long, elongated, pale-colored stems. The stems, which are horizontal and downward, change their growth direction in the dark (growing upward). In the light, cell elongation is inhibited, so the stems grow less in the same amount of time than in the dark. Exposure to sunlight causes the stems to acquire a bright color. Conclusion: no matter how the plant is positioned, its stems invariably grow upward.

This attraction to the sun allows the plant to more fully utilize the energy of sunlight, so essential for photosynthesis (Yakushina, 1993).

Conclusion

The importance of water in plant life cannot be overstated, as it is an essential component of cells. It turns out that tap water and snow water have different effects on plant growth and development. A bulb germinated in melted snow water grew significantly faster, likely due to the greater penetration of moisture into plant tissue. Tap water contains substances added to preserve pipes and disinfect water, which have an adverse effect on plants. Melt water stimulates growth because it contains more dissolved salts, essential for plants.

It is interesting to note that Russian farmers have used melt water for soaking seeds since ancient times. For example, it was recommended to sow beans only after soaking them in "winter water," obtained by melting March snow collected in May from forest ravines. To summarize our work, we can say that our goal and objectives have been achieved. We came to the following conclusion: for the best growth and development of plants, a combination of external factors (light, heat, moisture, atmospheric oxygen, mineral salts) is necessary.

Declaration of Competing Interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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