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The Impact of Climate and Soil on Crops Growth

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Abstract:

Plant growth has a direct impact on human livelihoods, and climate and soil conditions are key determinants of plant growth. Optimal plant growth requires an ideal environment, but global warming is increasingly disrupting these conditions, posing significant challenges to agricultural production. To optimize vegetable production in the face of these changes, the use of agronomic adaptation strategies, soil amendments, and effective management practices becomes essential. These combined approaches can help address the effects of climate change and soil variability, ultimately leading to improved crop quality. Despite the urgency of these issues, knowledge of how global warming specifically affects crop growth, yield and distribution is still limited. Potatoes, as one of the most widely cultivated vegetables globally, provide a valuable model for studying these complex interactions. Therefore, further research focusing on the interplay between climate, soil, and crop performance, with an emphasis on potatoes, is crucial for developing sustainable agricultural practices that can withstand the challenges posed by a changing climate.

Keywords: Climate, Soil, Potato, Agriculture.

1. Introduction

Plant growth is a part of agriculture. Agriculture is a study about growing crops and raising animals. It decides how crops are produced, and their taste. Plant growth is the increasing of plant volume and/or mass with or without the formation of new structures such as organs, tissues, cells, or cell organelles[1]. To achieve these increases, people need to have a series of practice steps for mutually reinforcing with stages of plant growth. The steps of agriculture practice are plowing, sowing, manuring, irrigation, weeding, harvesting, and storage. Four key points for growing vegetables: select crop, soil management, irrigation, and pest and disease control. People need to decide on the climate, soil type of the land, and also the needs of the market to decide on selecting a crop to cultivate[2]. Soil management uses organic fertilizers and chemical fertilizers rationally to maintain the fertility and structure of the soil and ensure the healthy growth of vegetables[3]. Carry out appropriate irrigation according to the water requirements and growth stage of vegetables to ensure moderate soil humid[4]. Then, regularly monitor pests and diseases and take scientific prevention and control measures to ensure the health of vegetables. The stages of plant growth are sprout, vegetative, budding, flowering, and ripening. Crops are a part of plants—especially vegetable crops. Vegetables are short-duration crops, grown in different seasons of the year and fetching higher economic returns[5]. It also provides people's bodies with abundant energy and nutrients that people need. Hence, how to grow the crops becomes significant. The factors that will affect vegetable growth are variable, however, they could be roughly divided into two parts, environmental factors, and biological factors, besides some human factors. However, the main factors will be climate and soil. These two affect the growth most. Nowadays, global warming is a severe problem that the world faces. It does change the climate seriously, but we are still not familiar with the effects of global climate change on plant growth, yield, and distribution are not fully understood. Soil degradation, salinization, and other problems affect plant growth. How to improve soil health. This means the study of the impact of climate and soil on crops is needed and cannot be ignored. Hence, this paper will demonstrate the factors of climate and soil, how they affect plant growth, and have a case, an example to better explain the impacts.

2. Factors Affecting Vegetable Growth

2.1 Climate and Vegetable Growth

Climate is a vital factor that affects vegetable growth. The main components of climate are the temperature, humidity, daylight, and wind conditions of a specific region. Photosynthesis is the process of using sunlight to convert chemical compounds into food. This is also a formation of carbohydrates that are used by plants to maintain their lives and support their growth. Plants in the world play a role in balancing the carbon dioxide and oxygen in the atmosphere. So, the increase of atmospheric carbon dioxide will increase the rate of photosynthesis of plants [6]. However, the climate and photosynthesis affect each other. The temperature will increase the rate of photosynthesis, according to the collision theory. increasing the temperature increases the average kinetic energy of the molecules, therefore the rate of photosynthesis increases. The daylight also increases the rate of photosynthesis by the energy source of photosynthesis. Then, when an environment has high humidity, the closing of stomata is reduced, allowing more carbon dioxide absorbed. Nevertheless, Excessive humidity may lead to the growth of pathogenic bacteria, thereby affecting plant health and photosynthetic efficiency. Proper wind strength could promote gas exchange and increase the supply of carbon dioxide, thereby increasing the efficiency of photosynthesis. Too strong wind could become harmful to leaves, which affects the competence of photosynthesis. The photosynthetic rate declined at higher wind speeds[7], for some plants, and some are contrary to it. However, any conditions should be in moderation, otherwise, they can be counterproductive and negatively affect the photosynthesis of the plant. This will directly impact the growth of plant growth.

Furthermore, to be more detailed on each main component of the vegetable growth. Different vegetables have different temperature requirements and, in general, too low or too high a temperature will inhibit their growth. Humidity has a direct effect on transpiration and water uptake in vegetables. Too much humidity could lead to the development of diseases, while too little humidity can cause vegetable leaves to lose water too quickly, thus affecting growth. Daylight is the main driver of photosynthesis in plants and is essential for vegetable growth. Adequate daylight can promote the production of chlorophyll and increase the efficiency of photosynthesis, thus accelerating the growth rate. Different vegetables have different needs for sunlight, and some leafy vegetables may suffer from leaf scorching when exposed to too much sunlight. Suitable winds can promote respiration and water evaporation, but too strong winds may cause mechanical damage to vegetables, especially to some plants with fragile branches.

Because of this, the plants will prefer to live in a certain environment or climate. Plant growth and geographic distribution (where the plant can grow) are greatly affected by the environment. For example, the heat-loving plant includes tomatoes and eggplant[8]. Carrots and cabbage will prefer cold weather further when a plant lives in an environment that is not their preference. Making a vegetable live in an environment that is not its preference. This makes the environmentally weak plant more susceptible to disease or insect attack.

2.2 Soil and Vegetable Growth

Soil is an important factor in plant growth. It also is a component of the environment plants live in. It provides structural support for plants used in agriculture and is also their source of water and nutrients[9]. It is a reservoir of essential elements such as nitrogen, phosphorus, and potassium, that plants need for growth and development. Nitrogen is the main component of chlorophyll, essential for photosynthesis in plants. An adequate supply of nitrogen can promote the growth of leaves, making them more green and luxuriant, thus improving the efficiency of photosynthesis, which in turn promotes the rapid growth of vegetables. Phosphorus plays an important role in energy transfer and metabolism. Also, it is particularly crucial for root development and plant flowering and fruiting. Sufficient phosphorus supply can promote the development of the root system, enhance the plant's ability to absorb water and nutrients, as well as promote the differentiation of flower buds, and improve the yield and quality of fruits[10]. Potassium has important effects on water regulation, enzyme activity, and stress tolerance in plants. Potassium can improve drought, disease, and cold resistance of plants, as well as increase the sugar content of fruits, and improve the taste and storage properties of fruits[10]. Trace elements such as zinc, copper, and manganese have an important effect on the photosynthesis and enzyme activity of vegetables, thus affecting their growth rate and biomass accumulation. When these micronutrients are deficient, plant growth is inhibited, resulting in reduced biomass, and less vegetable crop yield[11]. Then, elements such as iron and magnesium are essential for chlorophyll synthesis, and deficiencies. These elements can lead to the yellowing or mottling of leaves, which affects the efficiency of photosynthesis, and thus the health and growth of the plant[12-13]. Boron and molybdenum play an essential role in flowering and fruit development[14]. The deficiencies can lead to fruit deformities, reduced yields, and even affect the nutrient content of the fruit. Copper and manganese in the soil also increase the resistance of vegetables to diseases. When the content of these elements is insufficient, plants are more vulnerable to pathogens, resulting in stunted growth. As organic matter breaks down, these nutrients are released into the soil, creating a nutrient-rich environment that plants need to survive.

For soil, the country contains sandy soil, loamy soil, and clay soil. Different soils will have different performances in water retention and nutrient availability. Sandy soils are well drained but poor in water and fertilizer retention, which tends to lead to slow growth of vegetables; clay soils are strong in water and fertilizer retention but poor in aeration, which may lead to oxygen deprivation of the root system; loamy soils are in-between, and are usually considered to be the most suitable type of soil for vegetable growth.

The pH of the soil affects the plant's ability to absorb micronutrients and macronutrients. Most of the pH value of soil is around 3.5-10.0. Vegetables are suitable for growing in neutral to slightly acidic soils with a pH of 6.0 to 7.0. In excessively acidic or alkaline soils, the effectiveness of certain nutrients such as iron, manganese, and phosphorus is reduced, thus affecting the normal growth and development of vegetables. For example, in alkaline soils, phosphorus and manganese uptake is inhibited, resulting in yellowing of leaves[15]. The pH value of soil also affects microbial activity, which indirectly affects vegetable growth. Neutral to slightly acidic soils have high microbial activity, which contributes to the decomposition of organic matter and the release of nutrients, while at extreme pH levels, microbial activity decreases and the release of nutrients is slowed down, thus affecting nutrient acquisition and growth of vegetables[16]. Hence, the different plant will vary their need for soil also. Such as roses will like well-draining soil with a slightly acidic pH. Moreover, the vegetables such as carrots will more like sandy soil. The oak tree will like acidic soil and sandy soil, and soil that a pH value of around 5.0-7.0.

2.3 Interaction Between Climate and Soil

Soil formation is formed by five factors, Parent material, climate, organisms, topography, and time. Climate is one of the five factors, so it has a significant influence on soil properties. Soil organic carbon(SOC) is the carbon that remains in the soil after partial decomposition of any material produced by living organisms[17]. SOC is a significant factor in the fertility of the soil. Since it provides diverse energy sources for soil microorganisms, governs soil structure, and regulates the availability of organically bound nutrients[18]. Microorganisms are a nice helper for plants to absorb nutrients and water from the soil. Such as rhizobium. So, from this point, SOC provides an energy source to these microorganisms means indirectly helps plants to absorb nutrients and water. However, SOC and climate are interconnected. Climate variables, precipitation, and temperature influence the moisture availability in the soil. Further, these factors are the affection of the rate of decomposition of matter in soil. Hence, the climate would affect the rate of SOC formed in soil. Then affects the fertility of the soil, as known as the ability of soil to sustain agricultural plant growth.

Potato is a widely cultivated vegetable. cultivate potatoes a lot. Especially the Russet Burbank potato. So, the paper will as Russet Burbank as an example. The potatoes that grow up in different places have various appearances. The reason people love to grow potatoes is that they are easy to grow, easily accessible, and affordable. At the same time, potatoes are rich in nutrients. It contains vitamin C, vitamin B6, potassium, protein, carbohydrates, etc. To cultivate nice potatoes, you need a place with at least 6 hours of direct sunlight and fertile, well-drained soil, and loose, well-drained soil. The optimal moisture of soil for potatoes is 80 to 90% FC. The ideal temperature is around 20 to 25˚C. pH value is between 5.5-7.0. When a potato lives in a fertilized place, could have a cream-like texture. The acidity or alkalinity of the soil affects nutrient uptake and the potato's starch and moisture content. This in turn affects texture, with slightly acidic soils usually producing fluffier potatoes. Well-drained soil prevents water drainage, which makes potatoes tougher, while poorly drained soil may produce softer, more waterlogged tubers. Hence, sandy and loamy soil will be a nice choice for cultivating it. Cooler climates usually produce denser, more starchy potatoes, while warmer climates may result in softer, waxy potatoes. The length of the growing season and the temperature during tuber formation are critical. Potatoes grown at a steady moisture level tend to grow evenly, producing a more uniform texture. However, excess moisture can make potatoes more waterlogged and less firm. If potatoes grow up in an environment they prefer, people could get a better quality of potato. Hence, people could apply some strategies to alter the environment to get close to the ideal environment. Strategies of Agronomic adaptation strategies and Soil amendment and management practices could be a nice way for adaption. Agronomic adaptation strategies, such as changes in planting dates, fertilization, and irrigation, might sustain crop yield[19]. Soil amendment refers to the process of improving soil quality and plant health by adding organic matter and beneficial microbiota derived from underused biomass, as an alternative to chemical fumigants, to enhance the suppressive properties of the soil[20].

2.4 Suggestion for Vegetable Growth

This paper considers having an integrated approach, combining these two methods(Agronomic adaptation strategies and Soil amendment and management practices), more comprehensive to help adaption. In cool climates, select appropriate planting times, such as early spring, and use bio-cover to increase soil temperature, apply well-rotted organic fertilizer, and use black plastic film for soil temperature management. In arid and semi-arid climates, drought-tolerant varieties can be selected, organic matter added to increase soil water retention, cover crops used to reduce water evaporation, and limited water irrigation techniques implemented. In humid climates, select pest-resistant varieties and implement drainage management to increase soil drainage capacity and regular monitoring of soil moisture. In acid soils, raise soil pH with appropriate fertilizer and lime applications to increase organic matter and improve soil fertility. On neutral, fertile soils, crop rotation, and regular soil testing will be used to maintain soil health and pest control. By combining these strategies, growers can effectively improve the yield and quality of Russet-Burbank potatoes while promoting soil health and sustainable agriculture.

3 Conclusion

The climate and soil do have impacts on plant growth, which will straight to affect human lives. For example, colder climates result in denser, starchier potatoes, and more acidic soils produce fluffier potatoes. To achieve the ideal condition for vegetable growth could use the method of agronomic adaptation strategies and Soil amendment and management practices. The alteration adapted to the change of climate and the differences in soil. To aim to cultivate better crops. Global warming does change the world's climate. This will make much of affection. Some days the environment makes it hard to cultivate plants, so people need to figure out ways to deal with the problems. Being prepared for danger in times of peace. Not to mention the fact that we still don't know much about the effects of global warming on plant growth, production, and distribution. This means that it is necessary, and cannot be ignored, to study the effects of climate and soil on crops. The ever-changing environment and variable, unpredictable and unpredictable climate make the effectiveness of adaptation programs precarious. This unpredictability makes the study have limitations. Furthermore, there may be a degree of financial burden at first for farmers. In the future, Strengthen training and education for farmers, and provide policy support and subsidies to help them better understand and implement advanced agricultural adaptation strategies and soil management practices. And utilizing big data and artificial intelligence technology to monitor climate change, soil conditions, and crop growth in real time to have better agricultural management strategies. These two in the future may solve the limitation one day.

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