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Study on Importance of Environmental Factors on Wheat Productivity

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Abstract :

The plant growth and production mechanism is inhibited by abiotic stresses, and as a result, crop yield is decreased. Plants are usually subject to one or two or several abiotic stresses in the region. Crops typically exposed to essential abiotic stresses include drought, high temperature, salt deficiency, and nutrient deficiency. Stresses that are encountered by many plants affect their water status in common. The amount of water available has a significant effect on how climate change can affect areas around the globe (Kurukulasuriya, 2003). Drought, high and low temperature, and high salinity both cause the plants to respond in a peculiar way, with differing susceptibility and reaction. Plants that are affected by water stress show reduced growth and productivity. Changes in rainfall, temperature, and elevated ambient CO2 concentration have the greatest effect on plants, in general. While there is a lack of studies regarding the combined impact of variations in precipitation, temperature, and atmospheric CO2 concentration on wheat yield, there is some available evidence regarding the effects of each shift on wheat yield. Research suggests that drought is the most influential when it comes to minimal rainfall (Trethowan and Pfeiffer, 1999).

Introduction : Crop production is dependent on both biotic and abiotic influences. Temperature, CO2, water, light strength, and soil condition are the five primary factors that control plant development. C in the next 100 years. Temperatures in certain areas are predicted to climb above the global average (IPCC, 2013). Global climate rise in the 21st century is estimated to be between 0.15 and 0.6 degrees Celsius per decade, relative to temperatures that have prevailed in the last ten thousand years (Houghton, 2005). An era of resource scarcity, unhealthy soil conditions, drought, desertification, disease, and insect outbreaks on crops and seaside floods are all forecast to occur as a result of climate change (Kurukulasuriya, 2003). Agricultural production has undergone recent growth that has been unbalanced. Irregular weather conditions such as rapid temperature increases, severe winds, elevated levels of atmospheric carbon dioxide, increasing sea levels, or increased water or surface salinity became more likely because of climate change. There are two possibilities: a rise or a decline in plant yield (Ludwig and Asseng, 2005; Porter and Semenov, 2005).

Temperature and Salinity

The 21% of the world's grain and 200 million hectares of farmland is dependent on the global wheat harvest (Ortiz, 2008). It is possible that crop production in developed countries will be decreased by 20–30% due to rising temperatures brought on by climate change (Andersen et al., 1999; Asseng et al., 2015). Some reports have suggested that global warming, as a result of climate change, could pose a major threat to wheat yields, potentially increasing food shortages and poverty (Tubiello, 2000). Changes in average grain yield are delayed as a result of higher temperatures (Nicolas et al., 1984; Wheeler et al., 1996; Modhej et al., 2008; Narayanan et al., 2015). As the temperature rises by 1 degree centigrade, global wheat production is predicted to decline by 6 percent. These changes in temperature and precipitation would ultimately have a detrimental effect on wheat yields (Tubiello, 2000).

Plants may use adaptive techniques to deal with environmental tension. Plants use two different techniques to deal with two different forms of stress: Stress avoidance is the first technique, which lets the plant prevent stress factors or their effects from impacting plant processes. This is a secondary technique intended to tackle tension.

The plant's capacity to retain a comparatively high leaf water potential under conditions of water stress is known as hydration avoidance. Plants are able to withstand water stress through a variety of protection mechanisms. Water stress is the first plant reaction to low water content or low water capacity. Water uptake and water loss by transpiration are needed to maintain equilibrium between uptake and loss. It is possible for plants to do this in a number of ways, including by increasing water absorption and reducing water depletion through evapotranspiration. In order to optimize the amount of water that it will suck up, the plant needs to close the stomata, add more cuticle, and grow a wider root system. As long as water in the soil is sufficient for plant absorption, a plant's water capacity would not be affected even though transpiration is decreased. Water potential in the soil reduces as soil water content is low. As a result, plant water potential often decreases. Nevertheless, the plant has pathways to resist solute aggregation and cell wall hardening from decreasing water potential. Plant cells undergo a drop in water potential when solute amounts rise. This allows water to transfer from the soil or surrounding medium into the plant cells, where it has a low water potential (low water potential). Often, the leaf motions, the shedding of leaves, and the position of the leaves are also used as a reaction to water stress in plants (Morgan, 1984; Touchette et al., 2007). Plants reduce the amount of sunlight their leaves consume by leaf motions. Plants use motions like folding and rolling leaves to decrease the surface area. The advantage of leaf rolling is to shield the plant from leaf surface temperatures increasing as a result of increased solar radiation. Leaf rolling reduces the amount of radiation that is absorbed by leaf tissue. The method of leaf rolling decreases the rate of transpiration, resulting in water conservation for the plant. Water depletion by transpiration is minimized when the leaf is rolled up. In addition, certain plant species change their leaf structure in response to water stress. This involves a decrease in leaf area, less stomata, and an increase in the cell wall thickness. Plants use abscisic acid as another means to prevent dehydration. When plants are dehydrated, the water evaporates from the leaves, resulting in the leaves losing turgor and producing abscisic acid. Stomatal turgor loss also accelerates with abscisic acid use, and together they contribute to stomatal closure to save water. Stressed conditions make the plant more resistant to stomatal closure, which in turn lets the plant save water any plants use dehydration resistance techniques such as osmotic modification and cell wall elasticity (Touchette et al., 2007).

The most common source of dehydration resistance is reduced osmotic potentials. Most plants are able to survive dehydration stress by modifying their physical properties inside the plant and by using metabolic signals. Plant resistance mechanisms may be broken down into various mechanisms, including variations in membrane lipid structure, ion transporters, proteins, and antioxidants (Srivastava et al., 2012). often known as plant stress resistance, cells absorb solutes such as proline, glutathione, glycine betaine, mannitol, fructose, sucrose, raffinose, and polyamines, and as a result, plants provide stress tolerance (Krasensky and Jonak, 2012). osmoregulation plays an important part in helping the body withstand dehydration tension (Morgan, 1984). As the solutes found in plant cells increase, the cell's osmotic potential reduces, which results in more water being consumed by plant roots. Tissue elasticity was more critical for turgor control than osmotic modification, according to studies on plants like strawberry and black spruce (Blake et al., 1991). The last section of this sentence provides details about the way abscisic acid activates genes linked to drought resistance, precisely how it allows genes such as late embryogenesis abundant to be expressed (LEA).

Effects on Physiological and Biochemical Processes

In relation to plant growth and physiology, the temperature has a significant effect. Temperature is an important factor in plant growth and production, as a variety of biochemical reactions are susceptible to it. Other processes such as transpiration and water stress are also influenced by temperature (Evans and Rawson, 1969; Azcon-Bieto and Osmond, 1983). Heat stress can affect the structural and functional integrity of various proteins, membranes, and RNA organisms, and it can affect the performance of enzymatic reactions in the cell, which contributes to a metabolic imbalance (Hasanuzzaman et al., 2013). Water supply to the plant can be impacted by elevated temperatures, which could contribute to a rise in crop water requirements (Simoes-Araujo et al., 2003). This will impact plant physiology. To understand more about the developmental stage that is most influenced by high temperature stress, some researchers set out to investigate which one is impacted by high temperature stress. They discovered that when some temperate organisms are subjected to high temperature stress during the early stages of reproductive development, photosynthetic ability rapidly declines, and they drew the conclusion that this was analogous to an accelerated process of thylakoid membrane breakdown, which is an effect often observed in typical aging trends (Harding et al., 1990; Djanaguiraman et al., 2011; Pradhan et al., 2012a). Hot weather has a more profound impact on photosynthetic processes in higher plants, and the thylakoid membrane is especially vulnerable to high temperatures. It was observed in a study performed by Weis and Berry (1988) that an imbalance in carbon metabolism control inhibits the body's ability to efficiently use carbon dioxide. This shows in a decrease in ribulose-1, 5-bisphosphate carboxylase/oxygenase function. Additionally, elevated temperature results in reduced leaf chlorophyll content, and thereby contributes to accelerated senescence (Zhao et al., 2007; Pradhan et al., 2012a). Leaf senescence and membrane damage are commonly cited as causes of a reduction in chlorophyll content (Simon, 1974). Ultrastructural damage to chloroplasts, primarily breakdown of chloroplasts and the plasma membrane coupled with dilation of the thylakoid membrane, lowered the photosynthetic rate because of high temperature tension. Results of a study that looked at the effect of high temperature at the time of pollination found that high temperatures at this time foster leaf senescence and decrease radiation usage quality, while also decreasing the assimilate supply. Both of these result in a substantial reduction in spring wheat grain yield (Acevedo et al., 2002; Kobata et al., 2012). ROS aggregation (e.g. of singlet oxygen, the superoxide radical, hydrogen peroxide, and the hydroxyl radical) as well as ROS buildup during high temperature stress causes additional damage (Hasanuzzaman, 2012; Narayanan et al., 2015).

High Temperature Stress

Plant growth and production are greatly affected by the ambient temperature. Excessively high temperatures, which are known as heat stress for all living beings, are found above the optimum. Plants, on the whole, work with a very restricted temperature range. In the range of 0 °C to 40 °C, these two extremes can be called killing frosts and death by heat and dehydration, respectively. Some species of plants grow and evolve more rapidly within a given temperature range. This is the ideal growth range, which is defined as the temperature range where maximum growth occurs. the practical efficiency of most crops hits a height about 12 to 25 °C (Went, 1953; Abrami, 1972).

Effects of salinity stress

Plant growth and productivity would be significantly reduced worldwide if salinity was not a significant concern. Salinity is projected to affect over 800 million hectares of land by the year 2030, and for this reason, it is a serious obstacle to the food supply for an ever-increasing population (Rengasamy, 2006; FAO, 2008). Information on the salt content of soil is missing and there hasn't been an update in the last decade. Behnassi et al. (2013) observed that about 954.8 million ha of land is impacted by saline soils worldwide, according to Pessarakli and Szabolcs, as reported in Pessarakli and Szabolcs (2012). To be more productive, it is necessary to grow crops that use salt-affected land and saline water supplies effectively. At least 20% of the world's irrigated land is impaired by salinity and/or irrigated with salt water, according to Qadir et al. (2008). Another two million hectares of cropped land is being salt-affected each year (Rengasamy, 2006; Tuteja, 2007). By the middle of the 21st century, it is estimated that about half of the cultivated cropland will be destroyed due to salinization (Wang et al., 2007). Extreme evaporation losses from hot temperatures in arid and semi-arid areas contributes to salt build-up in the soil. But also in some of the world's sub-humid and humid climates, in coastal areas, the issue still persists. Salinity refers to the presence of the predominant dissolved inorganic solutes (namely sodium, magnesium, calcium, potassium, chloride, sulfate, carbonate, nitrate, and bicarbonate) in water and soil (Bernstein 1975; Tanji, 1990; Rhoades et al., 1999). Differential relationships between these salts as well as other ions are important, and can vary significantly between locations. As salt gets to a concentration that causes a loss in yield, this is known as a salinity crisis (Francois et al., 1999). Salts may derive from high water tables in irrigated areas, as well as those that occur in applied water. For certain countries, irrigation is the most significant source of salinity (Munns et al., 2004; Plaut et al., 2013). The extra salts that are held in irrigation water are released by mineral dissolution and weathering into the soil. Water evaporated from the soil solution can increase the concentration of dissolved salts in the soil solution (Gupta et al., 1990; Plaut et al., 2013; Francois et al., 1999). Seawater has inherently high levels of salt which induces salinity naturally. Since low rainfall is also associated with sandy soils, they are more prevalent in coastal regions where salt spray has reached the soil or water has absorbed the salts (Tanji, 1990). Even if an area has ample rainfall, there is the risk of salt deposition in soils with low drainage. The application of large quantities of fertilizer also increases soil salinity (Plaut et al., 2013). Coastal areas are home to high amounts of air salt, which can be transported to soil by water runoff (Gupta et al., 1990). A single source has a relative effect based on the individual drainage conditions, soil properties, water quality, plant water content, and cropping systems and management practices that are applied for crop production (Tanji, 1990). The growth of plants is either substantially curtailed or halted altogether due to the combination of inadequate soil moisture and elevated levels of soluble salts in the root region (Gupta et al., 1990). The three main ways salinity impacts crops is by osmotic stress, which reduces water availability; ionic stress, which induces ion homeostasis; and cellular ionic equilibrium, which then causes either nutrient depletion or toxicity (Kirst, 1989; Ahmad et al., 2010; Azooz et al., 2011; Carillo et al., 2011). Owing to the low osmotic potential of saline water, the plant is subject to secondary osmotic stress. During salinity stress, all of the physiological responses that arise from water deficiency stress can be detected (Qadir et al., 2008).

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