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Climate Change and Crop Stresses

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Abstract

In recent years climate change has brought about drastic changes in agro-climatic conditions resulting in posing a constant threat to crop production by environmental stresses. Among various environmental conditions including biotic and abiotic stresses play an important role in reducing crop productivity. Abiotic stresses cause higher crop loss as compared to biotic stress. Although a lot of studies have been conducted in plant stress research, it is of major importance for researchers to look for good adaption strategies as different abiotic stresses arise together in the field. These stresses have a detrimental effect on farmer's subsistence as well as the national economies and together with the current pandemic situation the global food security is put under threat.

Introduction

Climate change is expected to pose a serious threat to life on earth by bringing about drastic changes in the rainfall patterns and environmental conditions which will have a severe impact on agriculture. According to the Intergovernmental Panel on Climate Change (IPCC), plants experience stresses as a result of climate change and it has been ascertained to be the most influencing factor that affects agriculture at low lowlands which is predominately inhabited by developing countries. Due to climate change, plant pathogens and pests are also expected to evolve rapidly and with more virulent epidemics and severity. Furthermore, nutritional qualities of most crops will be reduced under elevated CO_2 concentrations brought about by climate change and in some crops it may even make it more toxic due to changes in the chemical composition of their tissues. Due to their interlinkage, the fight against these stresses is very complex with the major challenge being to understand how these plants respond to different stressors. Among the environmental issues, food scarcity is one of the biggest issues that need to be addressed. Therefore it is important that we update ourselves with the science of crop production to meet the challenges of overcoming the increasing food demand.

Productivity Losses Due to Stress

- It is estimated that 24.2% of the world's geographical area is potentially arable. But only 10.6% of area is under cultivation and the rest of the area is not accessible for cultivation due to one or more abiotic stresses.
- Abiotic stresses account for nearly 78% of yield losses.
- Annually about 42% of crop productivity is lost due to various abiotic stress factors.
- Drought can affect approximately 27% yield losses annually in the tropics.
- In India, about 7 m ha area is salt affected. This area

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constitutes about 17.5% of total potentially arable land in the country.

• Estimated global loss due to insect pests in potential yields of all crops is 14%.

• In India, losses due to insect pests range from 10-20%.

• Loss due to disease range from 20-30%. In case of severe infection, total crop may be lost.

• According to survey by Bayer Crop Science in 2008 they indicated a significantly higher crop losses caused by abiotic stresses than biotic stress (Figure 1).

Challenges of Multiple Environmental Stresses in Agriculture

Abiotic stresses, such as low or high temperature, drought or flood, high salinity and heavy metals toxicity are antagonistic to plant growth and development that leads to great crop yield loss worldwide. Temperature is the most effective factor affecting crop distribution followed by moisture and soil chemical properties which are also important factors. Each plant species and genotypes in particular has certain optimum range of temperature. If the temperature exceeds beyond this optimum range, it causes temperature stress in plants. Temperature stress may either be heat stress, chilling stress or freezing stress.

Elevated temperatures lead to changes in geographical arrangement along with alteration in crop growth season, resulting in early crop maturity. Field crops are highly sensitive to heat stress particularly during the reproductive stage than vegetative stage. Heat stress affects pollen development resulting in spikelet sterility and poor seed set ultimately resulting in decreased yields. Heat stress is normally accompanied by drought and salinity stresses and this further exacerbates productivity worldwide.

Drought stress is the most widespread factor in the world that affects productivity and climate change intensifies its severity. 1/4th of the world's land area is estimated to be dry while another 1/3rd area of cultivable land to be in acute water scarce condition. Drought can affect approximately 27% yield losses annually in the tropics. Soil drought is most common in arid and semi arid tropics and in areas of steep slope.

Salt stress or salinity stress is considered to be the second most common stress among abiotic stresses that limit crop productivity. It is estimated that 11125 million hectares of the world's area is affected by salinity of which human induced salinization accounts to 76 million hectares. Due to high levels of salinity irrigated lands are affected and millions of hectares of agricultural lands are rendered unsuitable for cultivation every year and 50% of cultivable lands will be lost by 2050 if it continues in this trend (Hasanuzzaman *et al*., 2014).

Other stresses of relatively low intensities that limit crop productivity include environmental pollutants toxicity from organic and inorganic chemicals, fertilizer and pesticide and heavy metal toxicity. Land degradation due to excessive cultivation, mismanagement of soil also contributes to threaten productivity worldwide. Additionally, biotic stresses like pests and diseases also contribute to loss in crop productivity globally though their extent of damage is estimated to be significantly lower as compared to abiotic stresses (Figure 1).

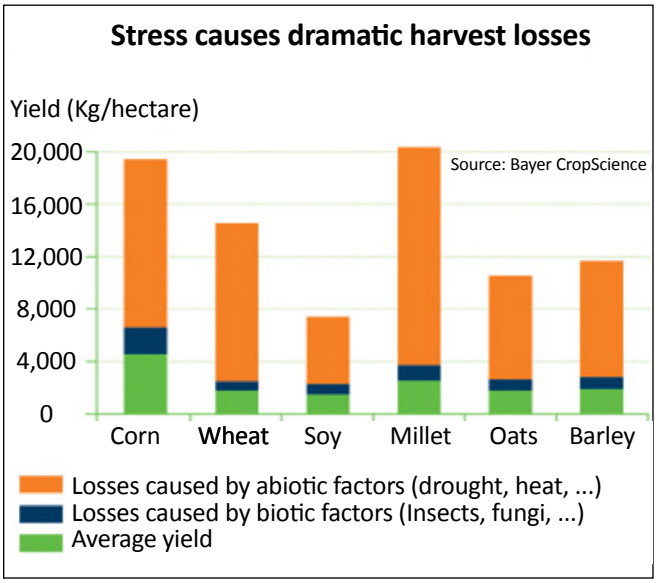

Figure 1: Estimated crop losses due to biotic and abiotic stresses. (Source: Bayer Crop Science 2008, http:// www.seedquest.com/ News/releases/2008/october/23973.htm)

Rising Food Insecurity and Covid-19

According to estimates of UN (FAO, 2020), in 2019 690 million people went hungry as compared to 2018 where it was 10 million. World Bank estimates that 100 million people could be pushed to extreme poverty by the impact of the pandemic. The increasing unemployment rates, decreasing incomes and soaring food prices will affect access to food in developing as well as developing countries which will pose a threat to global food security. Therefore, there is an increasing concern about post pandemic's impacts, particularly on vulnerable communities that are already struggling with hunger and other crises.

Strategies to Mitigate Challenges of Stress

Considering the severity of the prevailing situation worldwide it is imperative to devise a concrete approach in increasing the crop productivity. Approaches for overcoming plant stress can be achieved through conventional and advanced techniques. Water management, adjusting sowing time, soil manipulation, organic and inorganic nutrient

management, breeding techniques involving screening and selection from the available genetic pool, molecular and through conventional breeding methods and through molecular approaches like genetic transformation, tissue culture etc. Furthermore, losses incurring from different biotic stresses also need to be reduced through proper pest and disease management strategies. While all these approaches have an enduring impact, they are however small and slow. Therefore it is researchers must look for good adaptation strategies and important determinants to develop climate resilient crops.

Conclusion

Under present circumstances where there are regular dramatic changes in the environmental conditions finding an alternate option for increasing crop productivity is a major issue that needs attention to feed the ever increasing world population and ensure their food security. A lot of studies in the field of crop improvement programmes have been conducted in plant stress tolerance to biotic and abiotic stress. However, most of the studies does not explain their interactive effects therefore, we require a change in our focus on a single factor and understand the multiple stress response in plants and create different strategies to develop crops that maintain high yields under multiple stresses.

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