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Impact of Climate Change on Efficiency of Biocontrol of Plant Disease

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Abstract

A new revolution in agricultural innovation will be needed to sustain the food, fiber and fuel need of a growing global population and changing climate through the 21st century. Elevated CO_2 results in increased biomass that can modify the microclimate and affect the risk of pathogen infection. Change in temperature and precipitation regimes due to climate change alter the growth rate and pathogenicity of infectious agent and the physiology and resistant of the host plant. Climate change will induced adaptation process in plant and microorganism. Trichoderma species have beneficial effect on plant growth and enhanced resistant to abiotic stresses. At present several target traits and potential gene from diverse sources including microbes for engineering stress tolerance in crop plants to meet climate change challenge have been reported.

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Introduction

The widespread area of pests represents a difficult challenge for future agriculture. Scientists have found that on a global scale, pathogens and pests are reducing crop yields for five major food crops by 10 percent to 40 percent. Wheat, rice, maize, soybean, and potato yields are reduced by pathogens and animal pests, including insects, scientists found in a global survey of crop health experts. More incidence of disease pests, shortened *Rabi* season, increasing in temperature i.e. 0.68 °C in the last century, rising sea level etc. all these are climate change scenario in India. Change in temperature and precipitation regimes due to climate change alter the growth rate and pathogenicity of infectious agent and the physiology and resistant of the host plant. Disease management strategies may require adjustment under climate change.

Climate Change and Pathology

Plant pests are already causing substantial crop losses in most region of the world. An increase in extreme weather events and a trend toward warmer temperature may well worsen these impacts. Climate change is indeed not only going to threaten plant health, but may in some cases enhance it, estimating disease risk on a large scale is necessary for identifying research priorities, strategically orienting industry and developing public policies for establishing measures of adaptation that will allow the maintenance of food securities. Advances in technology for monitoring genetic responses in plants have enabled more accurate determination of how climate change results in modified expression of disease. These alter molecular mechanism determine the ability of plants to respond to environmental stimuli and adjust to new condition.

What Is Required?

- The effect of climate change on crop production and disease has to be focused.
- More work is needed to quantify changes in host pathogen interaction particularly for the important crop species under natural conditions.
- A thorough assessment of current management strategies and proposing alternative ones with a suitable transdisciplinary approach for the next decades will prepare us for the challenge of climate change.

Biorevolution

A new revolution in agricultural innovation will be needed to sustain the food, fiber and fuel need of a growing global population and changing climate through the 21st century. It could be based on

- Biological input through utilization of phytomicrobiomes (with inoculants, microbially produced compound etc.).
- Improved crop (by manipulation of the phytomicrobiomes community structure).

Critical Factor of Climate Change for Microbial Inoculants

- The critical factor that may affecting the activity of microbial inoculants in soil pH, environmental temperature and salinity of the soil.
- During the past 100 years, India has experienced significant increase of 0.6 °C surface air temperature which is considered higher than that for the previous century.
- The Indian soil has been characterized by pH values more than 7 and low to high salinity and ranged from being non-sodic to saline-sodic.

Effect of Climate Variability on Microbes

Most biocontrol agent performs best under a stable environment. However in addition to the forecast increase in mean temperature, CO_2 and shift in rainfall distribution, climate variability is expected to increase. Extreme weather events such as drought, flood and even unseasonal frost are predicted to occur more frequently. While many species have mechanism to cope with extremes, they require time to acclimatized or enter the resistant state.

Potential Factor of Elevated CO_2 Concentration on Beneficial Plant Microbe Interaction

The majority of studies indicated that elevated CO_2 levels will increase colonization of PGPF. This is generally in agreement with meta-analyses performed by Treseder (2004) and by Alberton *et al.* (2005), who reported positive plant and micorrhizal responses to elevated CO_2. The parameters indicative for fungal growth is highly important, particularly for being able to separate myco-centric and phyto-centric views. It is to note that elevated CO_2 concentration may induce AMF community composition changes (Klironomos *et al.,* 2005). The response of warming and drought will also depend on plant and the microbial genotype. The effect of elevated CO_2 on PGPB were more variable and no general trend in terms of increased or decreased abundance of PGPB has been observed so far. Climate change will induced adaptation process in plant and microorganism and might require the selection of adapted plant cultivars in agriculture. However adaptation process or the use of cultivar not fully adapted to new environmental condition could be supported by making use of plant growth promotion potential of PGPB. Particularly under elevated CO_2 condition, nutrient such as N might be limiting, leading to the need for enhanced fertilizer input in agriculture. Plant growth promoting microorganism supporting nutrient acquisition such as mycorrhizae or nitrogen fixing bacteria may thus gain increasing importance.

Encouraging Trichoderma

Trichoderma species have beneficial effect on plant growth and enhanced resistant to abiotic stresses i.e. salinity, drought, heat, chilling etc are the major abiotic stress. It help plants to resist these stresses via reinforcement plant growth, activation of the antioxidant machinery and defense signalizing pathway in root and shoot. It also secretes different compounds (auxin. Ethylene, gibberellins, plant enzymes, antioxidant) and compatible solutes and compound likes phytoalexins and phenol that provide tolerance to abiotic stress and enhance the branching capacity of the root system.

Sources of Transgene to Improve Stress Tolerance in Crop Plants

Genetic engineering is one of the alternatives to make crops more resilient to climate change. At present several target traits and potential gene from diverse sources including microbes for engineering stress tolerance in crop plants to meet climate change challenge have been reported. Single action gene like osmoprotectant, detoxifying gene, late embryogenesis abundant (LEA) protein, heat shock protein anaerobic poly peptides (ANPs) and ion transporter have potential in mitigating climate change effect. Multi action regulatory gene and single transduction gene may also be candidate gene for engineering stress tolerance. The Trichoderma genome contains numerous genes that are candidate as transgene such as chitinase, glucanase, lectin etc.

Future Issues

- Better screening assays for finding the next generation of MBCAs are needed to measure the overall effect of interplay of different mode of action.

• Multi-omics will help to further understand the complex events during microbial interaction in the environment.
• Current regulation on registration of MBCAs should allow a science based differentiation between the majority of compounds involve in modes of action to be considered.

Future Aspects

• Emphasis must shift from impact assessment to developing adaptation and mitigation strategies.
• Information about the dynamic and evolution of the pathogen has to be focused.
• Study needed to focus on the relationship between the pathogen dynamic and plant architecture.
• Disease risk analyses based on host pathogen interaction should be performed.
• Research on host response and adaptation should be conducted to understand how an imminent change in the climate could affect plant disease.

Conclusion

Elevated CO_2 results in increased biomass that can modify the microclimate and affect the risk of pathogen infection. Change in temperature and precipitation regimes due to climate change alter the growth rate and pathogenicity of infectious agent and the physiology and resistant of the host plant. Altered temperature may favour overwintering of sexual propagules thus increase the evolutionary potential of a pathogenic population. Model of plant disease have now been developed to incorporate more sophisticated climate predictions from general circulation models. Disease management strategies may require adjustment under climate change. Climate change will induced adaptation processes in plants and microorganism.

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