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Review

Paradigms of climate change impacts on some major food sources of the world: A review on current knowledge and future prospects

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ABSTRACT

Due to the adverse impacts of climate change on earth systems the research in this field has been profoundly taken a part in all scientific arenas since last few decades. The deleterious impacts of climate change on agricultural production are challenging the food security of the world in terms of quantity and quality both. Wheat, rice, maize, vegetables, fruits and fish-food provide food security for more than half of the world and are under immense pressure of changing climate. This review is an overview of the significant impacts associated with climate change on these food sources. In present synthesis, various phenological, physiological, biochemical and reproductive responses in major food crops have been summarized emphasizing the vulnerable growth and development stages. Winter and summer sensitivity responses, and morpho-biochemical acclimation patterns have also been summarized. Sustenance in wheat and rice production is evident but impacts of increasing temperatures are negating this on bio-physiological level impacts. Maize crops are experiencing more impacts on yield as compared to wheat and rice. Fruits and vegetable production is highly vulnerable to climate change at their reproductive stages and also due to more disease prevalence. Fisheries as a critical animal food source; is in extreme danger as apparent changes in their habitat and unmanageable environmental conditions are producing extreme losses. This review also provides an account of stress responses and useful adaptive measures. This synthesis may be helpful in understanding manifold dimensions and interactions of climate change impacts on selected major food sources of the world.

Contents

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1. Introduction

Climate variability has been and continues to be, the principal source of fluctuations in global food production in developing countries (Oseni and Masarirambi, 2011). The Earth's climate has warmed by approximately 0.6 °C over the past 100 years with two main periods of warming, between 1910 and 1945 and from 1976 onwards and is greater than any other time during the last 1000 years (IPCC, 2014). Undoubtedly, agricultural production is going to be affected due to its consequences and the magnitude of which on crop yields will vary locally due to regional differences in both natural and anthropogenic factors that control plant responses (Rustad, 2008; Wei et al., 2014). Coupled with resource scarcity of land, water, energy, and nutrients, declining soil quality, increased greenhouse gas emissions and surface water eutrophication, climate change will affect crop production in a great deal (Fan et al., 2011; Tripathi et al., 2014). Changing temporal and spatial trends of hydro-climatic variables, rising sea levels and increasing incidence of extreme events pose new risks to future food insecurity in all parts of the globe (Chen et al., 2015; Zhao et al., 2015). Anomalies in temperature and climatic regime of our earth system have raised the concerns to think global climate change as a strongest stressor for the agriculture and world food production since plants are directly related and respond to environment CO_2 and temperature (Kersebaum and Nendel, 2014). Therefore, the potential impacts of climate change on food security must therefore be viewed within the larger framework of changing earth system dynamics and multiple socio-economic and environmental variables.

Various critical direct and indirect consequences of global climate change on crop production can be seen due to the rising CO_2 and temperature and unpredictable rainfall disturbing the food security aspects of the world (Poudel and Kotani, 2013). Consequently it becomes quite important to examine the changes happening at different stages of the crop growth and development and their impact on the production either in the form of quality or quantity. As this subject has gained enormous importance in recent times with growing numbers of specific studies of the impacts of climate change on various food items; multidisciplinary synthesis of the knowledge of climate impacts on major food sources of the world is needed.

1.1. Climate change and its current scenario

The 'climate' may be referred as the characteristic weather conditions (viz. air temperature, precipitations, atmospheric pressure, humidity, wind, sunshine and cloud cover) of the earth's lower surface atmosphere at a specific location. Any change compared to prior observations in an existing observation record of the systematic measurements of these phenomena at a specific location over several years may be ascertained as climate change. However, an internationally agreed definition of the term "climate change" is still desirable which on different international platforms is regarded as (i) only human-induced changes in the climate system (UNFCCC, 2006), or (ii) all changes in the climate system, including the drivers of change, the changes themselves and their effects (GCOS, 2012); or (iii) long-term changes in average weather conditions (WMO).

The world is now frequently experiencing many unprecedented changes in climate due to warming of the earth's system since last five decades. The assessment report of IPCC (2014, AR-V) identifies the changes as well as gives various projections in current climatic variables. Each of the last three decades has been successively warmer than any preceding decade since 1850 imparting warmest 30-year period (1983–2012) in the Northern Hemisphere, in last 1400 years (IPCC, 2014). The atmospheric concentration of CO_2 has increased to the level of 396.48 μmol mol^{-1} in 2013 (ESRL-NOAA data, Fig. 1A) from its pre-industrial level of 280 ppm and is projected to reach 550 ppm by the middle of this century which may escalate up to 700 μmol mol^{-1} by the end of this century

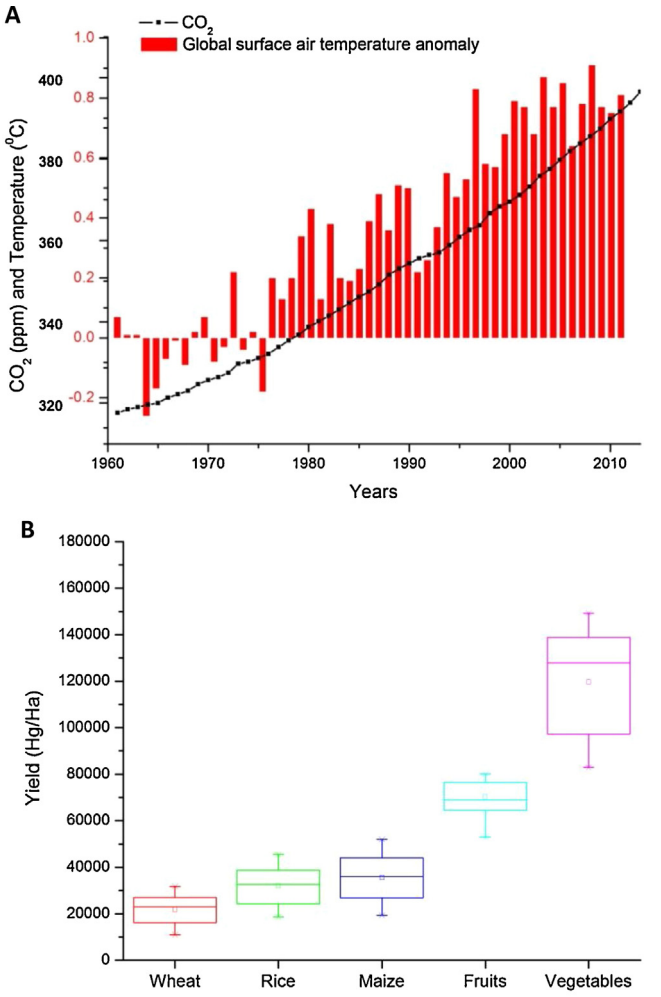

Fig. 1. (A) Annual mean of global surface air temperature anomaly (Base period: 1951–1980) and global CO_2 concentration since 1961–2013; shows equivalent increasing trends both in CO_2 concentration and temperature, indicating escalating warming of Earth systems (Data source: GISTEMP and ESRL, NOAA data). (B) The box chart shows variability in yield worldwide in selected food crops (excluding fisheries) since 1961–2012. Yield in selected food crops are showing departures from mean yield with respect to their minimum and maximum yield (Data source: FAO data). The boxes show first and third quartiles while whiskers show 5–95% intervals. The line in the boxes represents the median, and the small boxes, the mean value.