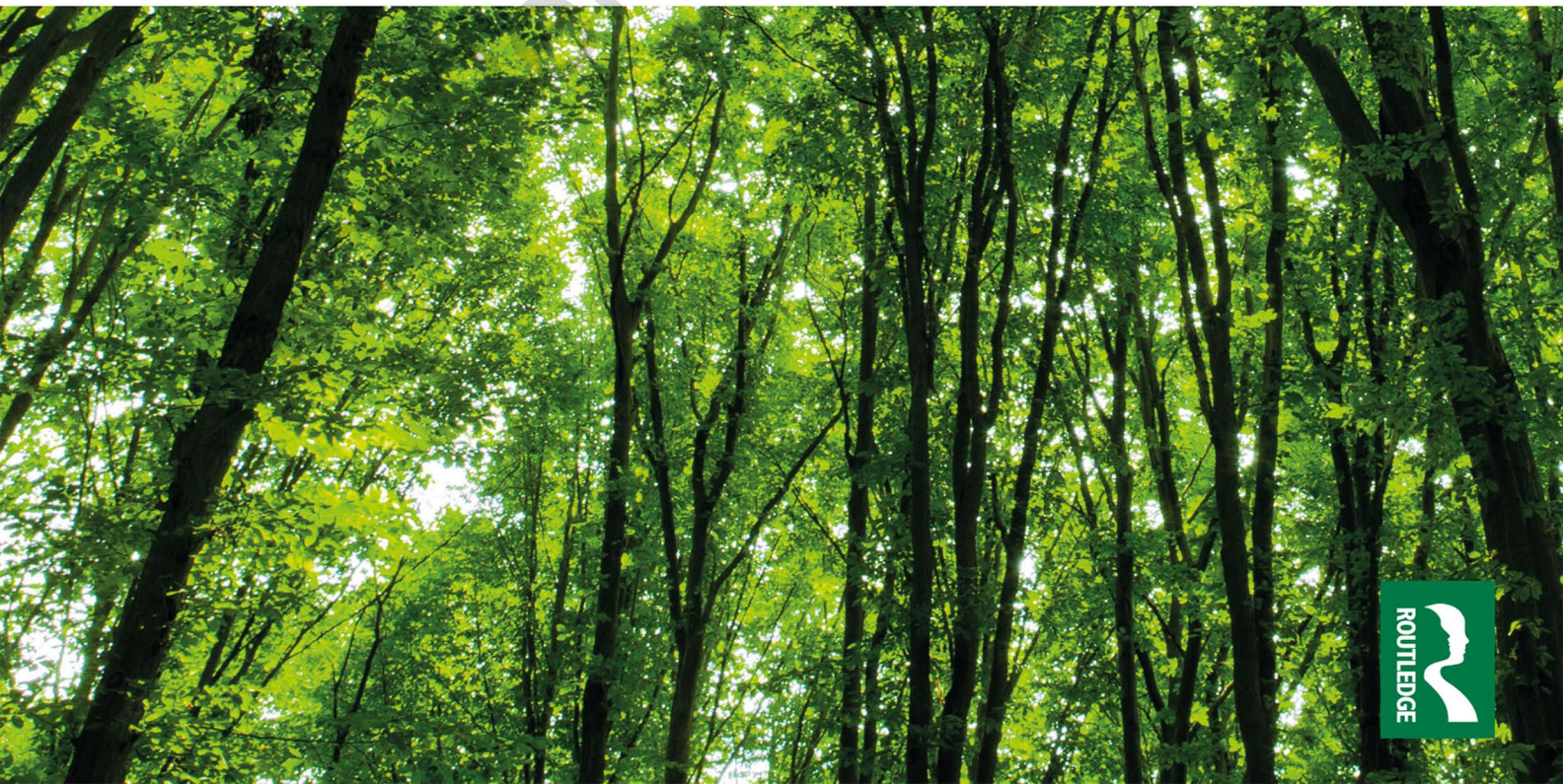
ECOPHYSIOLOGY OF TROPICAL PLANTS

RECENT TRENDS AND FUTURE PERSPECTIVES

Edited by
Sachchidanand Tripathi, Rahul Bhadouria, Pratap Srivastava,
Rishikesh Singh, and Rajkumari Sanayaima Devi



ROUTLEDGE

Contents

SECTION 4 Ecophysiological responses of tropical plants to disturbance events

SECTION 5 Ecophysiology and geoclimatic factors

5 Impact of Nitrogen Oxides on Tropical Plants

Aisha Kamal, Nida Sultan, Shazia Siddiqui, and Farhan Ahmad

5.1 INTRODUCTION

Between the latitudes of the Tropic of Cancer (23.5°N) and the Tropic of Capricorn (23.5°S), the tropics encircle the planet. These regions are biologically the richest ecosystem, characterized by the prevalence of rain in the humid areas close to the equator which becomes more seasonal as distance moves further from the equator (Laurance et al., 2012). In tropical and subtropical climates, high solar irradiance and heat can enhance photochemical reactions that result in the production and accumulation of many secondary contaminants such as peroxyacetyl nitrate (PAN), smog, and nitrogen oxides (NO_X) within the troposphere (Liu et al., 2022). In urban and industrial areas, NO_X are significant air pollutants. In the sunlight and the presence of other atmospheric gases, particularly O_3, NO_X stands for the total concentrations of NO and NO_2 in the atmosphere, which are inter-convertible. Automobiles, power plants, factories, incinerators, and high-temperature home activities include the principal sources of NO_X emissions. Significant increase in the use of automobiles and fossil fuels since the 20th century is principally responsible for an increase in nitrogenous air pollution (Brimblecombe & Stedman, 1982; Yunus et al., 1996, Perera, 2017). Agricultural soils are also considered as a major source for the emission of NO_X, the third-most-important greenhouse gas, caused by the microbial interactions with nitrogenous fertilizers (Bhadouria et al., 2019), and nearly 40% of the world's applications of nitrogen (N) fertilizers occur in tropical and subtropical areas (Xiankai et al., 2008). Over the past few decades, current nitrogen fluxes (NO_X, NO_3^-, NH_3, NH_4^+) are far higher than the expected natural flows to the atmosphere (Seinfeld & Pandis, 2016). The environment has suffered significantly as a result of these large-scale perturbations. The negative implications of this increased nitrogen flux include the acidification of soils, accelerated building and monument deterioration, and the development regarding secondary air pollutants (Tian & Niu, 2015; Mukherjee et al., 2019). In the major tropical West African city of Lagos, Nigeria, CO:NO_X ratio was found to be 150–200 times greater than the earlier reports (Odu-Onikosi et al., 2022). In various areas of Varanasi City, India, a remarkable increase (25.6–72.2%) in NO_2 was also reported over the past 20 years (Pandey et al., 1992; Mukherjee & Agrawal, 2016).

NO_X in the atmosphere has been recognized as a toxic pollutant and a crucial molecule in biological systems at the same time because of its roles as a regulator and messenger in plants and animals (Hayat et al., 2009). At higher concentrations, both NO and NO_2 act as phytotoxins, meaning that they can directly inhibit plant growth and decrease overall yield (WHO, 2000). It was reported that there are at least two indirect routes via which NO_X can function. Primarily, it is a crucial precursor for the production of ozone (O_3) and a phytotoxin that is known to lower crop yields (Mills et al., 2018). Second, NO_X is also a precursor to particulate matter aerosols which in presence of ammonia can result in increased concentrations of ammonium nitrate aerosols (NH_4NO_3), which is frequently the situation in agricultural areas due to the application of nitrogenous fertilizers like urea (Kharol et al., 2013; Lobell et al., 2022). These particles alter the radiation environment that crops experience and restrict access to radiation that is photosynthetically active, resulting in significant declines in crop quality and yield (Proctor et al., 2018: Proctor, 2021). It was also found in many investigations that NO_2 is more persistent and phytotoxic than NO, even at very less concentration. It causes visible damage and physiological aberrations (Mackenzie & El-Ashry, 1988). It was also found that nitrogen accumulation severely affects species dominance, richness, evenness, and abundance, and it has been considered as a major contributor to the loss of biodiversity (Bobbink et al., 2010; Vellend et al., 2017; Midolo et al., 2019). The damage caused by NO_X is typically invisible but manifests as slower growth and diminished output in terms of value and amenity. Very few studies have examined the impact of atmospheric NO_X. This chapter emphasizes on the beneficial as well as the adverse impacts of NO_X on the physiological processes of tropical plants, and is an effort to fill this gap and advanced knowledge of the issue.

5.2 POSITIVE IMPACTS OF NO_X ON TROPICAL PLANTS

Nitrogen is one of the essential macronutrients for the development of plants. Atmospheric nitrogen gets into the system through the stomata or roots (in the form of nitrates) and is reduced to nitrite and then ammonia by ferredoxin or nicotinamide adenine dinucleotide phosphate (NADPH) before its utilization (Jiechen et al., 2021; Prassad, 1996; Paneque, 1964). It has been hypothesized

DOI: 10.1201/9781003335054-7