Chapter 1

Introduction
INTRODUCTION

Healthy and suitable environment is essential for the existence of all living organisms of this planet. Environmental pollution in the present world has become a serious threat for survival of the living organisms of various kinds. Health and welfare of human beings are directly linked with viability and productivity of natural and agricultural products. Plants are life-supporting system on this planet and agricultural productivity is vital for human survival. Both the integrity and productivity of ecosystems are adversely affected by air pollution (Holdgate et al., 1982). With rapidly increasing industrialization for improving quality of human life, the quality of air is increasingly deteriorating and as a result concentration of phytotoxic air pollutants in the environment is gradually increasing. Pollutants are toxic substances responsible for environmental pollution. Pollutants in the atmosphere are generated by anthropogenic (man-made) and biogenic (natural) processes. Anthropogenic processes predominate in the industrial areas. A number of industries of various kinds release several obnoxious gases and particulates. Air pollutants may get adsorbed, accumulated and integrated in the plant body and at toxic levels, injure them variously (Rao, 1985). Plants have been classified into resistant, intermediate and sensitive categories based on their differential responses to specific air pollutant and combination thereof (Varshney, 1985). Pollution of the environment has increased enormously since the industrial revolution began in the 17th century.
Before this revolution, mankind had neither their number nor the technological and cultural potential for affecting a drastic change in the environment (Wolters and Martens, 1987). Among the pollution of various segments of environment, air pollution is the most dangerous. It adversely affects, directly or indirectly, the entire terrestrial vegetation, life of human beings and animals, and inanimate objects including the historical monuments. A large number of industries release substances, which are polluting all the sectors of the environment in different parts of the world. Thermal power plants, which are coal-based, rank among the worst air polluters in India. The main effluents from these power plants are SO$_2$, NO$_2$, NO and fly ash.

Since independence, India has made advancements in industrial, agricultural and technological fields, accompanied with fast urbanization. In rapidly growing cities, more traffic on roads, use of fossil fuels in outdated industrial processes, growing energy consumption and lack of industrial zoning and environmental regulations are contributing to the reduced urban air quality and deteriorating public health in the country. To improve economic and social well-being many developing countries have given priority to rapid industrial development. This has lead to progress and improved the material quality of life, but at the same time it could result in serious environmental deterioration, if not properly controlled.

Air pollutants affect the plants directly or indirectly. Since the plants derive more than 90% of their weight from the atmosphere, the quality of air is, therefore, critical for their growth and productivity.
The impacts of air pollutants on the crop plants are now being realized in different parts of the world (Heck et al., 1986). Gaseous air pollutants enter the leaves through stomata and cause various kinds of injuries and adversely affect physiological and biochemical processes of the plants which are eventually reflected in their growth and productivity. Particulate air pollutants like soil dust, coal dust, cement dust, fly ash etc. mostly fall and deposit on the leaf surface. This hampers transpiration, exchange of gases and checks the transmission of solar radiation (Darley, 1966). Both primary and secondary air pollutants, as classified by Wood (1968) based on their origin, are detrimental to the plant growth and productivity. Primary air pollutants, which originate at a source in a form toxic to living organisms, affect various kinds of plants. Effects of primary gaseous air pollutants such as sulphur dioxide, oxides of nitrogen, hydrogen fluoride, ammonia and ethylene etc. have been investigated and documented. Particulate air pollutants like coal dust, cement dust, fly ash, suspended particulate matters (SPM) etc. are also harmful to plants. Secondary air pollutants, which originate through reactions between primary air pollutants, are also inimical to plants. Harmful impacts of secondary air pollutants like PAN, O₃, and acid rain have been recognized.

Life processes in living organisms occur within a relatively narrow range of temperature, light, water and nutrients. Air pollution like any other adverse factor increases the normal stress on cells of living organisms that leads to various stages of impairment. Air pollutants are transferred to plant surfaces by deposition processes
including absorption and adsorption of toxic gases and gravitational settling of particulate matters (Pell, 1979).

Coal is the most intensive fossil fuel releasing 29% more carbon per unit energy than oil and 80% more than natural gas. Coal is the most abundant of the fossil fuels with an estimated 1000-year reserve. Two main ingredients of coal smoke are sulphur dioxide and particulate. They cause 5,00,000 premature deaths and millions of new respiratory illness each year in urban areas worldwide. Several cities including Delhi are near the pollution level that London experienced during its famous "fog" that took 4000 lives in 1952 (Rao and Rao, 1998).

Sulphur dioxide is one of the most prevalent and highly toxic gaseous air pollutants in India. It is the second most abundant contaminant next only to carbon monoxide (CO) accounting for about 20% by weight of all air pollutants. The concentration of sulphur dioxide for industrial areas has been recommended as 0.042 µgm$^{-3}$ by the Central Pollution Control Board, India. But in many areas the concentration normally exceeds the prescribed safe limit. It stings the eye and causes a burning sensation in the throat.

Sulphur is essential for plants and animals in trace amounts and its natural level of occurrence is not harmful in most situations. However, with growing industrialization the level of SO$_2$ concentration is rising day by day. SO$_2$ emitted through coal burning depends upon the sulphur content of the coal, which varies from 1-6% of the total weight. The concentration of SO$_2$ decreases rapidly with the distance
from the source and meteorological and topographical conditions. The concentration of $SO_2$ near coal burning power plants and smelters with little or no pollution control equipment has been found to be as high as 1 to 3 ppm. $SO_2$ in large urban centres ranges from 0.05 to 0.4 ppm. The extent and nature of injury/damage caused by air pollutants are determined by genetic and environmental factors of the plant, as well as by the concentration and exposure duration to the pollutant (Heagle, 1973, 1982).

$SO_2$ in the leaves after entry through the stomata reacts with water in mesophyll tissue to produce sulphite ions, which are slowly oxidized to sulphate ions. The sulphate ions may be utilized by the plant as nutritional sulphur and converted into organic form (Thomas et al., 1943). But the sulphite ions are toxic to plant cells when present in excess. $SO_2$ affects both physiological and biochemical processes of the plants. Photosynthesis of affected plants is generally reduced, but the transpiration and dark respiration are increased. In some cases, enzyme activities increased by exposure of plants to low level of $SO_2$ and decreased by its higher concentration (Horsman and Welburn, 1977; Soldatini and Ziegler, 1979; Wyss and Brunold, 1980; Pierre and Quieroz, 1982; Tanaka et al., 1982). Sulphur dioxide is a prevalent gaseous pollutant in India and other developing countries. Some studies indicate that ambient concentration of the gas around coal based thermal power plants may range from 43-348 $\mu$gm$^{-3}$ (Khan and Khan, 1996). $SO_2$ gas causes disorders in plants with specific symptoms (Khan and Khan, 1993).
Air pollution is a new factor in agriculture. A number of air pollutants are known to affect growth and productivity of crop plants (Khan, 1996). Oil seed crops, which have great contribution in agricultural economy of the country like India, have not been adequately examined for their performance under air pollution stress. Effect of fungal diseases in stressed conditions on oil seed crops has received very little attention and the influence of any air pollutant or a mixture of various air pollutants on disease severity is yet to be fully investigated. Plants under field conditions are continuously exposed to more than one pathogen, at a time. Some of these pathogens interact to cause disease complexes. In nature there is another type of multiple pathogen interaction between biotic and abiotic pathogens. The ambient environment of an urban industrialized area contaminated by several pollutants emitted from different sources affect plants, plant parasites and their parasitism. The impact of air pollutants on parasitism may be direct or indirect. The parasitism may be increased or decreased as a result of the direct effect of the pollutants on the parasites, or the effect may be indirect through pollutant induced changes in other aspects of the environments (Heagle, 1973).

According to Shafer et al. (1985), three distinct kinds of relationships exists between air pollutants and plant pathogenic microbes while co-occurring in a common pathosystem i.e. neutral relationship, antagonistic relationship and synergistic relationship. The latter two are more logical and practically possible. The available literature on biotic pathogen - air pollutant - plant interactions provides ample evidence in support of all possible relationships (Heagle, 1973;
Khan and Khan 1993). Air pollutants appear to stimulate as well as depress activity of parasites, depending upon several factors such as concentration of the gas, type of the pollutants and pathogen etc. Available knowledge indicates that obligate parasitism is increased by pollution stress. Diseases caused by obligate plant pathogens like *Uromyces phaseoli*, *Puccinia graminis*, *Erysiphe graminis* and *Sphaerotheca fuliginea* etc. were inhibited due to air pollutants (Heagle and Strickland, 1972; Laurence et al., 1979; Wiedensaul and Darling, 1979; Lorenzini et al. 1990; Khan et al., 1991). However, diseases caused by *Botrytis* spp., *Armillaria mellea* and *Scirrhia acicola* were enhanced when exposed to air pollutants (Heagle, 1973; Rist and Lorbeer, 1984).

India is the world's 3rd largest edible oil economy after USA and China. It occupies a distinct position not in terms of area of cultivation but also in terms of diversity in cultivated oil seeds in the world. Selecting two important oil-seed crops (rapeseed and sunflower) this work has been carried out in green houses, under controlled condition with the following objectives:

(a) to study the impact of the increased level of SO$_2$, above the ambient level of the air of the exposure chamber, on the physiomorphological characteristics, the yield attributes and seed yield, at harvest of both the crops.

(b) to assess the practical applicability of fly ash in improving crop productivity by its amendment to the soil or dusting to the foliage at various stages of growth.
(c) the rapeseed plants are naturally exposed to the fungi, *Alternaria brassicicola* to cause significant damage to the plant and a reduction in seed production. These diseased plants were exposed to SO₂ or fly ash, applied to the soil or foliage, with a goal to explore gains by their interaction effect with the pathogen or the host.