EFFECTS OF OXIDES OF SULPHUR AND OXIDES OF NITROGEN ON PLANTS

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Different types of air pollutants such as oxides of sulphur, oxides of nitrogen, ozone, carbon monoxide, chlorine fluoride etc. have been recognized in the atmosphere. Their concentration is increasing in the heavily industrialized and densely populated areas. Damage to agricultural, forest and ornamental plants species caused by air pollutants has been reported in different parts of the world. The effects of oxides of sulphur and oxides of nitrogen on plants are of significant interest due to their higher concentrations in the polluted atmosphere. SO_2 is emitted in the air whenever sulphur-containing fossil fuels such as coal and oil are burnt. Oxides of nitrogen are of more recent occurrence due to the development of the internal combustion engine and the large scale manufacture of nitric acid and nitrogenous fertilizers.

The benefits from plants are not limited. Their importance in urban centers is recognized today more than ever. Air pollution levels are high enough in some areas to cause plant damage. The toxic effects of SO_3 on plant have been known since 1948, although earlier observations do exists, whereas oxides of nitrogen has been recognized as damaging only over the last few years.

It is suggested that the level of SO_2 required to cause visible injury to many sensitive plants are about 0.5 ppm for 2-4 hours, whereas some of the indigenous plants of the south-west desert of the United States may be 10 to 20 times more resistant. However, SO_2-sensitive plants are able to tolerate SO_2 upto 0.1 ppm for prolonged period without injury. Long-term field experiments in Sudbury, Ontario, with low concentration of SO_2 indicated damage to white pine (Pinus strobus) and aspen (Populus termula), as well as to some sensitive plants, such as buckwheat, barley and red clover. According to earlier workers (5,6) no effect was observed on higher plants below 0.3 ppm SO_2 but the recent work in Britain showed that SO_2 below 0.15 ppm can be harmful.

Stomata or small openings on the leaf surface play an important part in regulating the uptake of pollutants. At night when stomata are closed, the plants can tolerate a higher concentration of pollutants than during the daytime. It is demonstrated that some pollutants effect plant growth by reducing light intensity, blocking off stomatal pores and the toxicity of certain constituents of smoke, either directly or indirectly through the soil. It is important to note that entry of pollutants into leaves is not limited only through stomatal pores but that other factors such as boundary layer resistances can occur in such fumigation systems where the air movement is inadequate across the leaves. In such situations, boundary layer resistance might control the entry of pollutants through the stomata. Ashenden and Mansfield (1) showed that ryegrass was unaffected at 0.1 ppm SO_2 at a wind speed of 10m min^{-1} whereas at a wind speed of 25m min^{-1}, the same concentration caused 30 percent reduction in the growth over a period of four weeks.

Damage by oxides of nitrogen was mentioned first by Benedict and Breen (2) but no attention was paid until 1960 by which time there was an increase in the concentrations of oxides of nitrogen particularly due to traffic and large production of nitrogen fertilizers and nitric acid. As with SO_2, most of the earlier workers were engaged in attempting to define a "Threshold" concentration of NO_2 for each plant species. This was perhaps best explained by some of the Americans, who fumigated many agricultural plants in small chambers with different levels of NO_2 and found a sharp threshold level for physical leaf damage for their species somewhere between 10 and 15 ppm. These are extremely high levels of NO_2 which would be unlikely to occur in most natural situations. That one can no longer measure the sensitivity of a plant purely in terms of the average concentration of the pollutant and the duration of exposure of the plant to that pollutant has been established by later workers. Many attempts have been made to categorize plants according to their sensitivity to oxides of nitrogen, but recently much variation has been

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found in the sensitivity of plants even of the same variedly. The sensitivity of a particular variety of plant to oxides of nitrogen is not constant but depends on the environmental conditions such as temperature, humidity, wind speed etc.

Visible damage to cotton and dwarf beans has been noticed (3) when these plants were fumigated to 1.0 ppm NO_2 for 48 hours Wellburn *et al.* (8) found damage to chloroplast of broad bean (Vicia faba) similar to that caused by SO_2 with 1.0 ppm of NO_2 for 1 hour. Therefore, reduction in yield is a possibility where occasionally high concentration occur in the field condition.

Such situations in which there is only one pollutant present are rare. Industries and urban sources emit one or more pollutants into the atmosphere already polluted by a number of toxic substances. Therefore, in order to recognize and understand actual situation in the field, it is necessary to study the effects of mixture of gases on plants.

It has been found that the combined effect of SO_2 and NO_2 together on plant is greater than their separate effects. The response is at least an additive one, and there may often be a synergistic interaction, SO_2 in the presence of NO_2 (which acts as a catalyst) forms a sulphuric acid aerosol in the moist atmosphere. Furthermore, it is reported that the photochemical reaction rate of SO_2 in the atmosphere is increased more than 10-fold in the presence of NO_2. It is not clear whether their mixed effects on plants are the result of reactions in the air before entering the plant tissue or after they have entered the cells. Aerial damage caused by SO_2 and NO_2 mixture was first reported by Heck (4) and Tingey *et al.* (7). The latter workers found that the threshold level for causing physical injury are much lower for a SO_2/NO_2 mixture than for either pollutant separately.

At the end I conclude by saying that in our country we do not know the magnitude of the effects of air pollutants on plants. To make any advancement in this field we must know the levels of different pollutants in the atmosphere, enlarge our understanding of the environmental conditions, maintain a critical attitude to the experimental methods and consider the genetic variation of our vegetation and economic plants.

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