Environmental Entomology (Ent-703) Credit Hours 2(2-0)

Lecture # 6 Delivered by Dr.Hassan Yasoob

Topic- Impact of Pollutants on Insects and Non-target Organisms at Different Levels

High levels of pollution found in many of the world's major cities are having negative effects on plants and insects, according to new research from the University of Sheffield. The study, published in *Nature Communications*, reveals that plants exposed to high levels of nitrogen dioxide (NO_2) – similar to levels recorded in major urban centres – are able to better defend themselves against herbivorous insects.

Led by Dr. Stuart Campbell from the University's Department of Animal and Plant Sciences, the research has discovered that plants exposed to increased levels of pollution produce more defensive chemicals in their leaves.

Results from the study show that insects feeding on these leaves grew poorly, which suggests high levels of air pollution may be having cascading negative effects on communities of herbivorous creatures.

Dr. Campbell, who is also part of the P3 Centre – a centre of excellence for translational plant science at the University of Sheffield, said: "Nitrogen dioxide is a pollutant that causes severe health problems in humans, but our research has found that it may also be having a significant impact on plants and insects.

"Insects are a crucial part of nature and the world we live in. Insects are critical to the healthy functioning of ecosystems.

"Many people may be aware that insect pollinators, such as the thousands of species of bees, along with flies, moths and butterflies, are crucial for food production – but they also ensure the long-term survival of wildflowers, shrubs and trees."

Dr. Campbell added: "Insects that feed on plants (herbivorous insects) help return plant nutrients to the soil, and are themselves food for wild birds, reptiles, mammals, and yet more insects. Insects are also immensely important for decomposing decaying organic matter and maintaining healthy soils. Scientists are warning about massive declines in insect numbers, which should be incredibly alarming to anyone who values the natural world and our sources of food.

"Nitrogen dioxide is a major component of smog and is an example of pollution caused from human activity, particularly our reliance on fossil fuels. Levels of this pollutant in the atmosphere remain particularly high in cities, and especially in the UK. Our research shows another example of the dangers of pollution to our environments and the reasons why we need to make a united effort to tackle it."

The international team of scientists, which includes a researcher now based at the US Environmental Protection Agency, also looked at whether insects have an effect on the ability of plants to absorb NO_2 from the environment.

Plants that had been fed on by insects absorbed much less NO_2, according to the study. The authors believe this indicates that insects could be influencing the amount of pollution removed from the air by urban green spaces. Urban trees can absorb gaseous pollutants like NO_2, but the effects appear to vary between species and locations, and this may be due in part to the actions of leaf-feeding insects. Dr. Campbell emphasised, however, that the primary concern would be for the insects themselves, and that further research is needed: "Research suggests that urban vegetation plays a modest role in taking up NO_2. More work is needed, because many factors may influence the effect of urban plants on air quality, including herbivory. Plant feeding insects, however, face a number of different human threats, potentially including air pollution."

The study, "Plant defences mediate interactions between herbivory and the direct foliar uptake of atmospheric reactive nitrogen," is published in the journal Nature Communications.

Effects of air pollution on the searching behaviour of an insect parasitoid

To assess the impact of air pollutants on the population dynamics of herbivores, the effects of pollutants on their natural enemies including predators, parasites, and pathogens must be evaluated in addition to direct effects and indirect effects mediated via the host plant. Insect parasitoids are an important group of such natural enemies providing many examples of partial or complete biological control of pest species. This study examined the effects of air pollutants (ozone (O_3), sulphur dioxide (SO_2), and nitrogen dioxide (NO_2)) on the searching behaviour of insect parasitoids.

A series of experiments comprising short-term, closed chamber fumigations of O_3, SO_2, and NO_2 (100 nl l^{-1}) of the braconid parasitoid (*Asobara tabida*) and aggregated distributions of its host larvae (*Drosophila subobscura*) was set up. Analysis of chamber results showed that the proportion of hosts parasitised and the searching efficiency of the parasitoids were both significantly reduced with O_3 fumigation, but not with NO_2 or SO_2 fumigations. O_3 fumigation reduced percentage parasitism by approximately 10%.

Parasitoids were able to avoid patches with no hosts, both in filtered air controls and when exposed to pollutants. However in the O_3 and NO_2 treatments they appeared less able to discriminate between different host densities, suggesting that pollutants may interfere with the olfactory responses of the parasitoids.

These results indicate the potential for air pollutants, particularly O_3, to negatively influence the searching behaviour of parasitoids, and hence reduce the efficiency of natural enemy control of many pest species.

Effects of Air Pollution on Herbivorous Insects

The effects of air pollution on vegetation, in particular reduction in the economic yield of crops have been studied for many years. Various estimates have been made of the economic impact of different pollutants in this respect in both USA and Europe, while more recently interest has started to grow in developing countries (Ashmore et ai., Shamsi et ai., this volume - Chapters 3 & 6, respectively). The best estimate of such effects was produced by the USA National Crop Loss Assessment Network (NCLAN) programme, carried out in the 1980s. This employed a rigorous common protocol in which experimental plants were grown to maturity in open-top chambers ventilated with air containing a range of 0 3 concentrations in order to generate dose/response relationships. On the basis of the NCLAN study it was estimated that the current direct economic impact of 0 3 alone on the ten most important crops in the USA amounted to about $ 3 x 109 per year (Adams et al., 1988). This was equivalent to about 2.8% loss on annual production over the country as a whole. However, comparison with losses due to other stresses indicates that the latter are of a considerably greater magnitude, e.g., a 33% reduction in the annual production in USA resulting from attack by fungal pathogens and insect pests (Bell et al., 1993). It is well known that a wide range of environmental factors can modify the response of plants to air pollution, including temperature, relative humidity, wind-speed, light intensity, soil water status, and mineral nutrition. However, it is only relatively recently that interest has developed in the possible impacts of air pollution on the response of plants to other, more familiar, environmental stresses, both abiotic and biotic, e.g., drought, salinity, frost, fungal pathogens, viruses, bacterial pathogens and insect pests. In view of the great importance of many of these stresses in reducing the yield of agricultural crops and forestry, it could be argued that any impact of air pollution, either positive or negative, upon these responses could have major economic significance. In this chapter a brief review is given of some of the demonstrated impacts of air pollutants on one of these stresses - herbivorous insect pests of a range of vegetation types. It will draw heavily, but not exclusively, upon the extensive programme of research carried out in this field at Imperial College over the last 15 years. For a more exhaustive review the reader is referred for further information to: Alstad et al. (1982), Baltensweiler (1985), Hain (1987), Hughes (1988), Manning & Keane (1988), Riemer & Whittaker (1989), McNeill & Whittaker (1990), Bell et al. (1993) and Brown (1995).

Neonicotinoids in bees: a review on concentrations, side-effects and risk assessment

Neonicotinoid insecticides are successfully applied to control pests in a variety of agricultural crops; however, they may not only affect pest insects but also non-target organisms such as pollinators. This review summarizes, for the first time, 15 years of research on the hazards of neonicotinoids to bees including honey bees, bumble bees and solitary bees. The focus of the paper is on three different key aspects determining the risks of neonicotinoid field concentrations for bee populations: (1) the environmental neonicotinoid residue levels in plants, bees and bee products in relation to pesticide application, (2) the reported side-effects with special attention for sublethal effects, and (3) the usefulness for the evaluation of neonicotinoids of an already existing risk assessment scheme for systemic compounds. Although environmental residue levels of neonicotinoids were found to be lower than acute/chronic toxicity levels, there is still a lack of reliable data as most analyses were conducted near the detection limit and for only few crops. Many laboratory studies described lethal and sublethal effects of neonicotinoids on the foraging behavior, and learning and memory abilities of bees, while no effects were observed in field studies at field-realistic dosages. The proposed risk assessment scheme for systemic compounds was shown to be applicable to assess the risk for side-effects of neonicotinoids as it considers the effect on different life stages and different levels of biological organization (organism versus colony). Future research studies should be conducted with field-realistic concentrations, relevant exposure and evaluation durations. Molecular markers may be used to improve risk assessment by a better understanding of the mode of action (interaction with receptors) of neonicotinoids in bees leading to the identification of environmentally safer compounds.