# Assessment of Impacts of Air Pollution on Crops in South Asia with a focus on Tropospheric Ozone

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## Aim of crop impact assessment study

- To identify agricultural areas in South Asia at risk from ozone ($O_3$)
- To quantify – based on field experiments across the region - the effect of ambient $O_3$ on crop yields in South Asia
- To identify the sensitivity of important South Asian crops to $O_3$
- To inform model-based regional crop impact assessment studies
- To increase awareness of $O_3$ effects on agricultural among policy makers, scientists and the interested public
- To build capacity in South Asia in application of risk assessment methods
- To establish a global network of crop effect scientists

  → To gain knowledge of threat $O_3$ poses on food security in South Asia

## Methodology

Chemical protectant study using EDU

EDU suppresses acute and chronic ozone injury on a variety of crop plants (e.g. Mung bean, wheat, potato, spinach, tobacco) under ambient $O_3$ conditions (Godzik & Manning, 1998)


***Structural formula for N-(2-(2-oxo-1-imadazolidinyl)ethyl)-N'-phenylurea***

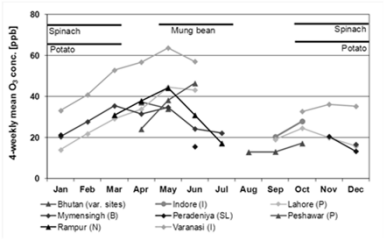
***abbreviated as EDU for ethylenediurea***


**Pakistan soybean cv. NARC-1 showing protective effect of EDU at a roadside rural site in Lahore, Pakistan (photo courtesy of A. Wahid)**

## Overview of sites and crops used

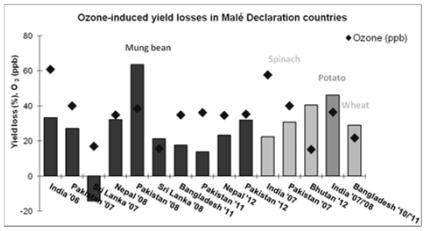
| Country | Site | Scientist in charge | Crop |
|---|---|---|---|
| Bangladesh | Mymensingh | Prof. M. A. Sattar, Dr. T. Islam | Mung bean, Wheat |
| Bhutan | Kanglung | Dr. K. Tshering, Dr. M. Pelmo | Spinach |
| India | Varanasi | Prof. M. Agrawal | Mung bean, Spinach, Potato |
| Nepal | Rampur | Prof. N. Chaudhary, Mr. L. Amgain, Ms. M. Bhattarai | Mung bean |
| Pakistan | Lahore, Peshawar | Prof. S.R.A. Shamsi, Dr. M.N. Ahmad | Mung bean, Spinach |
| Sri Lanka | Peradenyia | Dr. A. Perera | Mung bean |

## Ozone concentrations in South Asia




Four-weekly mean ambient ozone concentration monitored using passive samplers at various sites across the South Asian region.

## Yield losses in South Asia



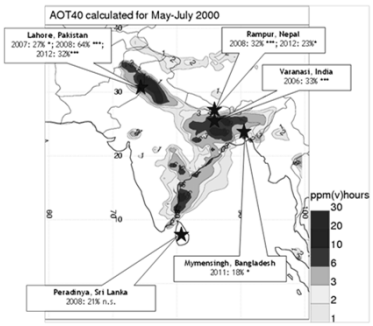

Ozone-induced yield losses for Mung bean, spinach, potato and wheat in various South Asian countries as recorded during field experiments conducted between 2006 and 2012.

## Visible evidence of $O_3$ effect


Example shown from Lahore, Pakistan (Photos courtesy of Prof. Shamsi).
Left photo: Spinach; right photo: Mung bean

Beside obvious difference in growth and hence yield, ozone-induced leaf injury (depending on crop varying between brown, yellow or whitish stipples of various sizes) makes it more difficult to sell leafy crops on market; customers prefer healthy looking, bright green leaves!

## Modelled $O_3$ concentrations *vs*. field-based evidence




MATCH-modelled $O_3$ concentrations for year 2000 (as 3-month AOT40 values for May – July) and results of EDU chemical protectant study for mung bean (% yield loss) conducted at South Asian experimental sites (blue stars) during equivalent months. The significance of the experimental results is presented (n.s. = not significant; * moderately significant and *** highly significant).

## Establishment of Air Pollution Crop Effect Network (APCEN)

- To facilitate communication between air quality stakeholders concerned with assessing risk posed by air pollution to agriculture
- To provide technical support to the experimental campaigns of Malé Declaration crop impact assessment studies
- 70+ network members (mainly air pollution effects scientists, modellers and policy makers) are located across the globe

| Region | Network Members | Countries / regions represented |
|---|---|---|
| **Africa** | **14** | Egypt, Kenya, Mozambique, South Africa, Zimbabwe, Zambia, Tanzania, Botswana |
| **Asia** | **55** | India, Japan, Nepal, Pakistan, P.R. China, Philippines, South Korea, Sri Lanka, Taiwan, Thailand, Bangladesh |
| **The Americas, Europe and Australia** | **18** | Australia, Chile, Sweden, UK, USA, Brazil, Germany |

## Summary of achievements

- New large-scale experimental evidence of effects of $O_3$ on yield of important South Asian crops (e.g. Mung bean, spinach, wheat and potato); evidence fits well with modelling-based regional prediction of $O_3$ concentration fields;
- Wide-spread evidence of plant-damaging concentration levels of $O_3$ during main growing seasons of important South Asian crops;
- Development of standardised risk assessment methodologies that have been evaluated for application across South Asian region;
- Increased awareness of yield-damaging effect of $O_3$ among policy makers, scientific community and general public through seminars, training workshops and information material (e.g. policy briefs);

## Summary of achievements (cont.)

- Successful capacity building in region due to training of numerous junior and senior scientists in application of risk assessment methods;
- Enhanced, institutionalized (e.g. via APCEN network and GAP Forum) cooperation between South Asian, European and North American scientists with active mutual exchange of knowledge and skills;
- A Regional Centre of Crop Impact Assessment is currently being established in Pakistan to oversee coordination, harmonization, quality control and reporting of the Malé Declaration crop impact activities.

## Future challenges – knowledge gaps

- Better estimation of extent of yield losses of staple crops due to air pollution across entire South Asian region → link to food security!
- Identification of differing $O_3$ sensitivity of common crop cultivars cultivated in region;
- Effect of changing climate (temperature, rain fall) on crop growth and yield
- Robust estimation of extent of socio-economic effects of $O_3$ and climate change on crop yields for small- to large-scale farmers in region.

## Suggested future steps

- Modelling studies to enable derivation of dose-response relationships for crops in South Asia;
- Pan-Asian Open Top Chamber (OTC) study;
- Crop impact studies that account for changing climate (temperature rise, change in rainfall patterns and hence shift of growing seasons).

→ this will require strong joint proposal writing efforts of Asian, European and North American scientists, a clear political will in South Asian region and potent donors.