

# Ozone biomonitoring: How relevant are results from tobacco (*Nicotiana tabacum*) cv. 'Bel W3' ?



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## Introduction

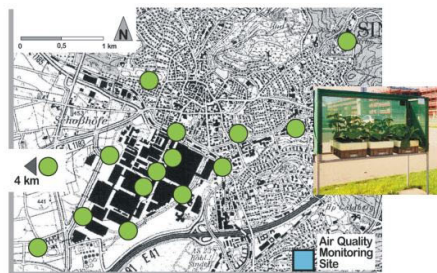
Ozone ( $O_3$ ) is one of the most important air pollutants worldwide causing plant injury and yield losses. Air pollution effects due to ozone are frequently assessed by the highly sensitive 'Bel W3' cultivar of tobacco (*Nicotiana tabacum*).

The relevance of this biomonitoring species, however, is sometimes questioned with respect to representativeness towards natural vegetation and other crop species due to its subtropical origin.

Thus, leaf injury data were evaluated from various biomonitoring species, which were exposed in a local network around a large automotive plant. While the chief purpose of this network is to assess potential effects due to solvent emissions [1,2], other injury symptoms, e.g. typical ozone injury, were also recorded.

## Material and Methods

A biomonitoring study was initiated in 1992, comprising the area of the automotive plant and the nearby City of Sindelfingen (see map) with the number of monitoring sites varying from 7 to 13 in the course of the study.



Map: Biomonitoring network in the Sindelfingen area

Various crop and ornamental plant species (Tab. 1) were exposed from May through September/October for consecutive intervals of 2 or 4 weeks, using standardized shaded exposure racks with continuous water supply [3,4]. Different symptoms of leaf injury (necrosis, chlorosis, senescence, oxidant injury) were assessed and estimated in % leaf area.

Tab. 1: Plant species and varieties exposed and assessed during field monitoring 1992-2002

Species	Variety	92	93	94	95	96	97	98	99	00	01	02
Tobacco	'Bel W3'											
<i>Nicotiana tabacum</i>												
Bush bean	'Pinto'											
Phaseolus	'Sanilac'											
vulgaris	'Saxa'											
Tomato	'Estrella'											
Lycopersicon	'Master'											
esculentum	'Roma'											
Nasturtium	'Niedere'											
Tropaeolum	'Rankende'											
majus	'Whirlybird Scarlet'											
Sunflower	'Frankasol'											
Helianthus	'Goldener Neger'											
annuus	'Riesen-Sonnenbl.'											

Data of ambient ozone concentration from the nearby Air Quality Monitoring site (see map) were kindly provided by the State Environmental Agency (LfU Baden-Wuerttemberg). Ozone concentration and dose statistics as mean, median, 75- through 99-percentiles, avg. daily maximum, avg. daily-8h-maximum, AOT20 through AOT70 (cumulative  $O_3$ -dose >20, ..., 70 ppb during daylight hours).

## References

- [1] KOSTKA-RICK R. et al. (1995). In: ARNDT, U.; FOMINA, LORENZ, S. (Eds.): Bioidication - 1. Hohenheimer Workshop zur Bioidication 1995; 257-264. Heimbach, Ostfildern (Germany).
- [2] HAHN, H.-U.; KOSTKA-RICK, R. (2002). In: KLUMPP, A.; FOMINA, LORENZ, S.; ANSEL, W. (Eds.): Bioidication and Air Quality in European Cities. 3. Hohenheimer Workshop on Bioidication 2001; 119-130. Heimbach, Ostfildern (Germany).
- [3] ARNDT, U. et al. (1985): Standardisierte Exposition von pflanzlichen Reaktions-indikatoren. Staub - Reinhaltung der Luft 45(10): 481-483.
- [4] VDI 3957/6 (2003): Method of the standardized tobacco exposure. Biological measuring techniques for the determination and evaluation of the effects of air pollutants on plants (bioidication). VDI/VIN Handbuch Reinhaltung der Luft, Beuth, Berlin (Germany).
- [5] DAVIS, D.D.; KRESS, L.W. (1974): The relative susceptibility of ten bean varieties to ozone. Plant Disease Reporter 58: 14-16.

## Abstract

The use of 'Bel W3' tobacco and its representativeness to European plants has been occasionally questioned due to the subtropical origin of this highly sensitive monitoring plant for ambient ozone pollution.

Data on oxidant leaf injury in various crop and horticultural species (bush bean, tomato, nasturtium), used as sensitive biomonitoring plants for solvent air pollution and exposed in parallel with 'Bel W3' tobacco over several years, have been evaluated.

## Results and Discussion

**'Bel W3' tobacco:** Typical oxidant leaf injury in 'Bel W3' tobacco is highly significantly related to various  $O_3$ -concentration and dose statistics (Fig. 1). Inclusion of relevant climate variables (temperature, VPD) via a multiple regression model only marginally improved this relationship:  
 $O_3$  (95-percentile) only:  $R^2=0,736$  ( $p<0,001$ )  
 $O_3$  (95-percentile) + VPD:  $R^2=0,750$  ( $p<0,001$ )

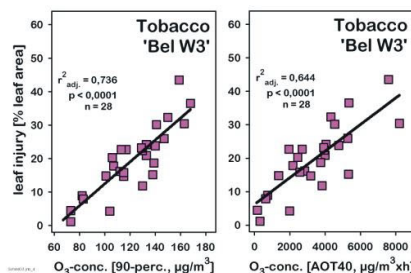
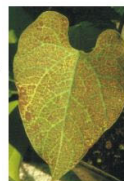


Fig. 1: Extent of typical oxidant leaf injury [% leaf area] in 'Bel W3' tobacco vs.  $O_3$  concentration (90-percentile) or cumulative dose (AOT40). Each datapoint represents the mean value of 6-12 sites and a total of 12-22 plants x 3 leaves/plant

**Bush bean:** Bronzing of leaves as a typical symptom of oxidant injury [5] is significantly related to  $O_3$ -concentration. Oxidant injury of >5% leaf area was observed when  $O_3$ -concentration (90-percentile) exceeded  $110 \mu\text{g}/\text{m}^3$  ('Pinto') and  $130 \mu\text{g}/\text{m}^3$  ('Sanilac'). The extent of leaf injury was lower in 'Sanilac' compared to 'Pinto' bean (Fig. 2).



**Extent of oxidant injury in 'Sanilac' bean, however, was more clearly and linearly related to the extent of tobacco 'Bel W3' leaf injury than to any of the 23  $O_3$ -concentration or dose statistics evaluated (Fig. 3).**

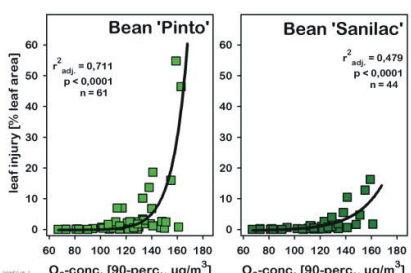


Fig. 2: Extent of oxidant leaf injury [% leaf area] in 'Pinto' and 'Sanilac' bean vs.  $O_3$  concentration (90-percentile). Each datapoint represents the mean value of 6-12 sites and a total of 16-48 plants x 2 primary leaves/plant

For most species typical oxidant injury was significantly related to ozone concentration or dose, often showing threshold phenomena. Frequently, however, oxidant injury in these species was more clearly related to the extent of 'Bel-W3' tobacco injury than to any conventional ozone concentration or dose description.

This may indicate that 'Bel W3' tobacco is sufficiently representative for other crop species when exposed under similar conditions.

## Results and Discussion (cont.)

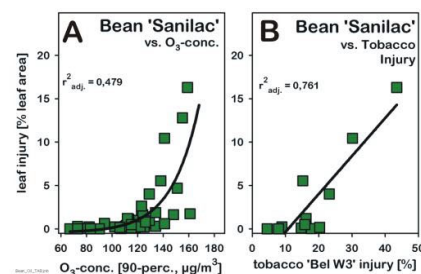
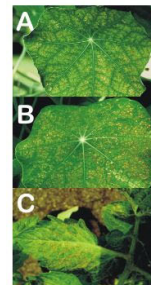


Fig. 3: Oxidant leaf injury in 'Sanilac' bean vs.  $O_3$ -concentration (90-perc., A) and vs. tobacco 'Bel W3' injury (B)

**Nasturtium, tomato:** Necrotic stipple, occasionally mixed with interveinal chlorosis, occurred in 'Whirlybird Scarlet' nasturtium (Fig. 3 A+B) and in the 3 varieties of tomato (C) mostly during episodes of elevated ambient  $O_3$ . Oxidant injury symptoms observed in nasturtium in the field (A) have been previously confirmed by controlled  $O_3$ -fumigation (B).



**For all tomato varieties, a better and more significant linear relationship was found between oxidant injury and tobacco injury than with any  $O_3$ -concentration or dose (Fig. 4, var. 'Roma' shown only).**

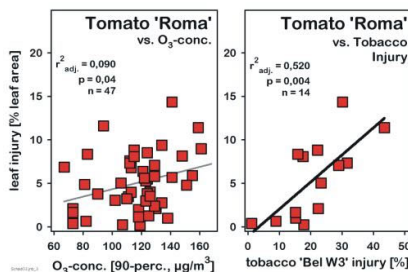


Fig. 4: Oxidant leaf injury in 'Roma' tomato vs.  $O_3$ -concentration (90-perc., A) and vs. tobacco 'Bel W3' injury (B)

## Conclusion

The extent of oxidant-type leaf injury in 'Bel W3' tobacco may provide a better basis for risk assessment (incidence or extent of oxidant leaf injury) in some other crop species (e.g. bean, tomato) than does conventional concentration or dose statistics of ambient ozone.

This biomonitoring study is performed continuously since 1992 for DaimlerChrysler AG, Sindelfingen, from 1992-1997 by TÜV Süd-west/Energie und Umwelt, Filderstadt, since 1998 by the author.