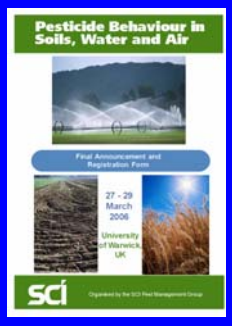
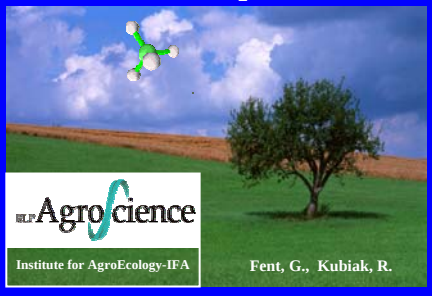
Large scale outdoor wind tunnel experiments to investigate the volatilisation and short range transport of Lindane



Fate and transport in air



Outline:

- Background and motivation
- Test system presentation
- Results
- Summary and “Take Home Messages”

Non-target pesticide contamination via dry/wet deposition ?

DT_{50} air?

LRT SRT

0-100% emission?

How to measure volatilization of pesticides?

Laboratory		Field
Artifical surfaces	Plant surfaces	
Surface area few cm^2	Surface area up to 1 m^2	Surface area up to 10000 m^2

How to measure volatilization of pesticides?

Reality

Validity

Transferability

Reproducibility

How to fill the test system gap between Lab and Field?

Semi-outdoor wind tunnel

Nearly realistic outdoor conditions, but more reproducible boundary conditions in order to identify factors influencing volatilization of pesticides at field scale

Semi- outdoor wind tunnel bridging Lab to Field?

Adjustable wind speed	yes	no
Constant wind direction	yes	no
Air flow / atmospheric stability	laminar/artificial	chaos
Outdoor temperature/humidity fluctuation	yes	yes
Natural daylight	yes (80%)	yes
Natural plant canopy	yes	yes
Application according GAP	yes	yes
Duration application	30 sec	> 5 min
Wash-off by rainfall	no	yes
Photo degradation	no	yes

Field studies to assess the volatilisation behaviour of pesticides can provide

- e.g. the order of magnitude of volatilisation under the specific test conditions
- but suitable only to a limited extent to investigate influencing factors under field conditions

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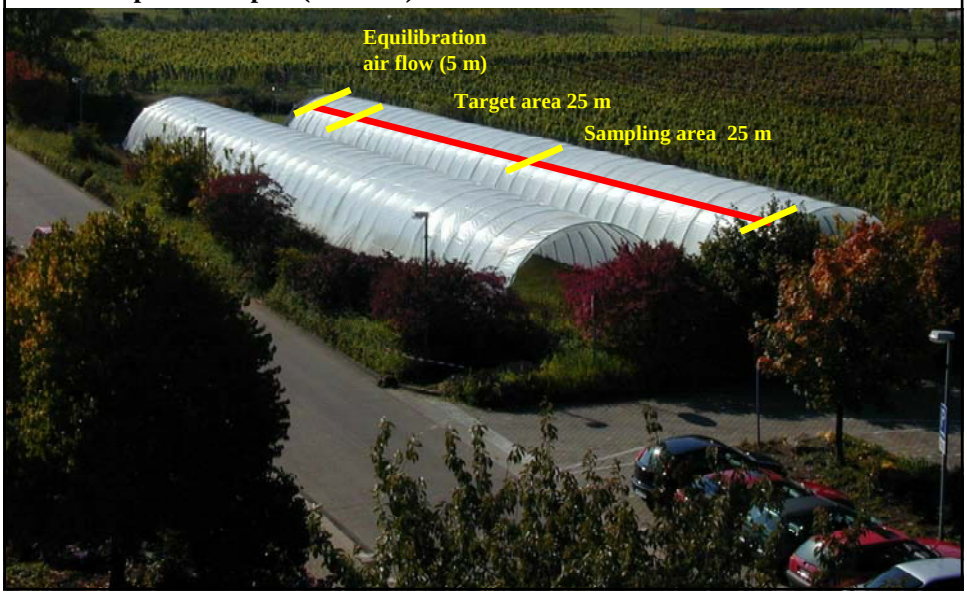
The Test System - Wind tunnel

Steady-going adjustable wind speed in one direction

100 m² crop covered plot (25 x 4 m) under outdoor conditions



• **26 synchron running axial flow fans (40 kW)**

• **Wind speed from 0.1 bis 5.0 m^{-s}**

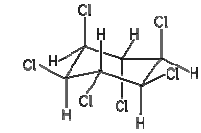
The wind engine

Applications to winter wheat

BBCH Code 51-69, > 90 % interception, LAI up to 8

Applications to sugar beet

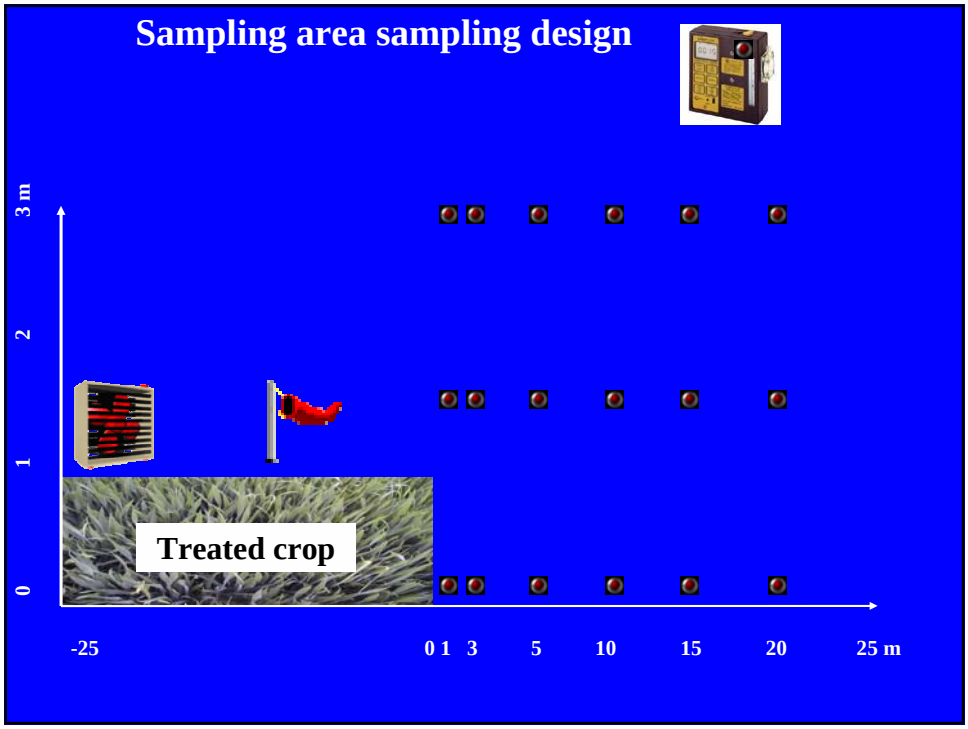
BBCH Code 39, > 90 % interception, LAI up to 4

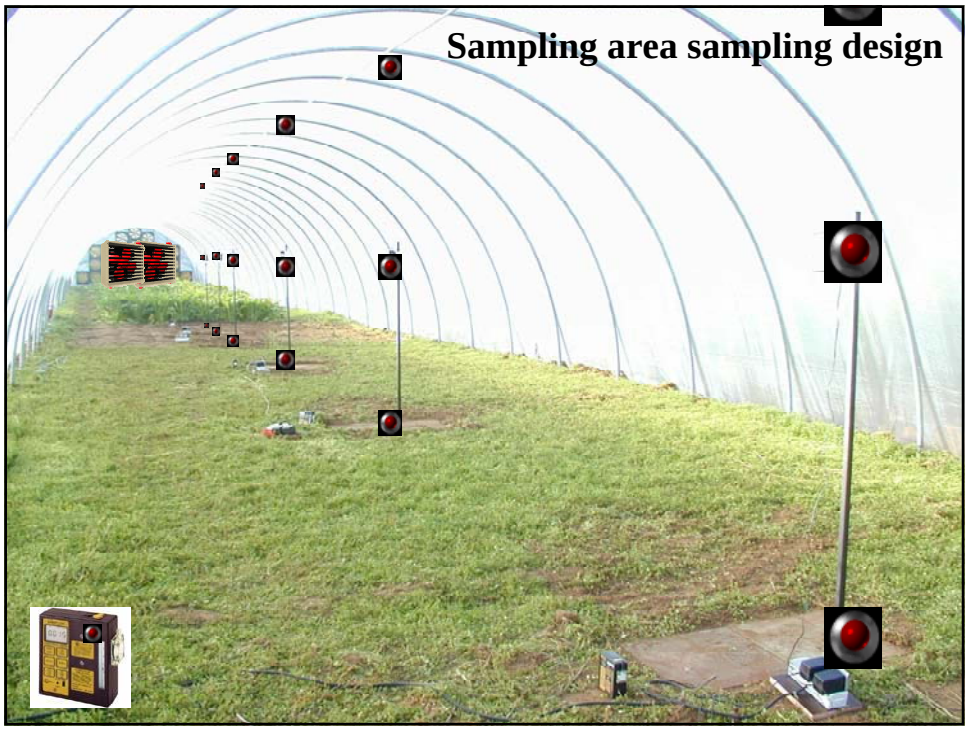


Lindane as Test Substance. Why?

- well known pesticide with high volatilization potential (90% within 24 h from plants)
- was investigated both, at laboratory and field scale
- easily to extract from Tenax tubes, simple detection and quantification via GC-ECD
- temperature dependency was demonstrated in lab-studies (46 to 80% / 15 vs. 23°C)
- stable in the environment (no competitive processes like photo degradation)

- Due to the high volatilization potential (about 90% within 24 h from plants) of Lindane, it can be used in the wind tunnel test system as an internal standard for the classification of pesticides with unknown emission behavior


Sampling area sampling design
3 m
2
1
0
Treated crop
-25
0 1 3 5 10 15 20 25 m


Sampling area sampling design

Sampling intervals and analytical methods

Time dependent sampling scheme:

1, 3, 6, 12 and 24 h after application

Analytical method: GC-ECD

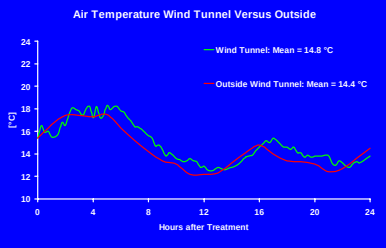
Experimental set up and basic parameters

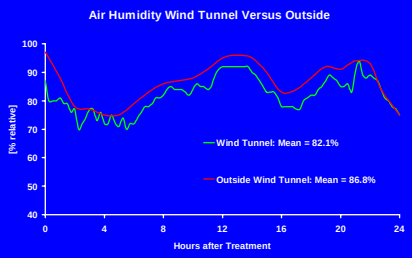
- 15 Wind tunnel experiments with an application rate corresponding to 200 g/ha lindane
- All applications according GAP to crops (WW and SB) with > 90% spray interception
- 9 applications to SB and 6 applications to WW
- 11 experiments with wind speed 2 m/sec and 4 experiments with 4 m/sec

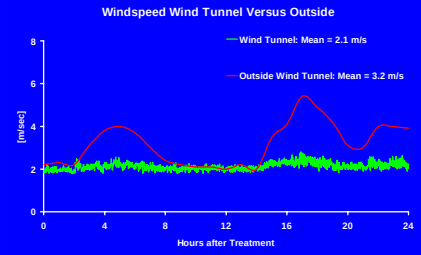
Results within the scope of the experimental design

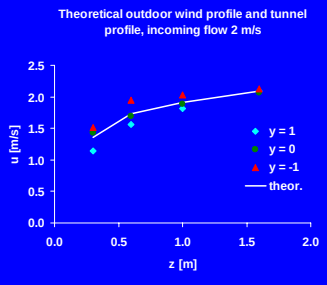
- Wind tunnel characteristics
- Volatilization of Lindane
- Influence of temperature and crop
- Influence of wind speed
- Time dependent volatilization behaviour

Whether conditions field vs. wind tunnel

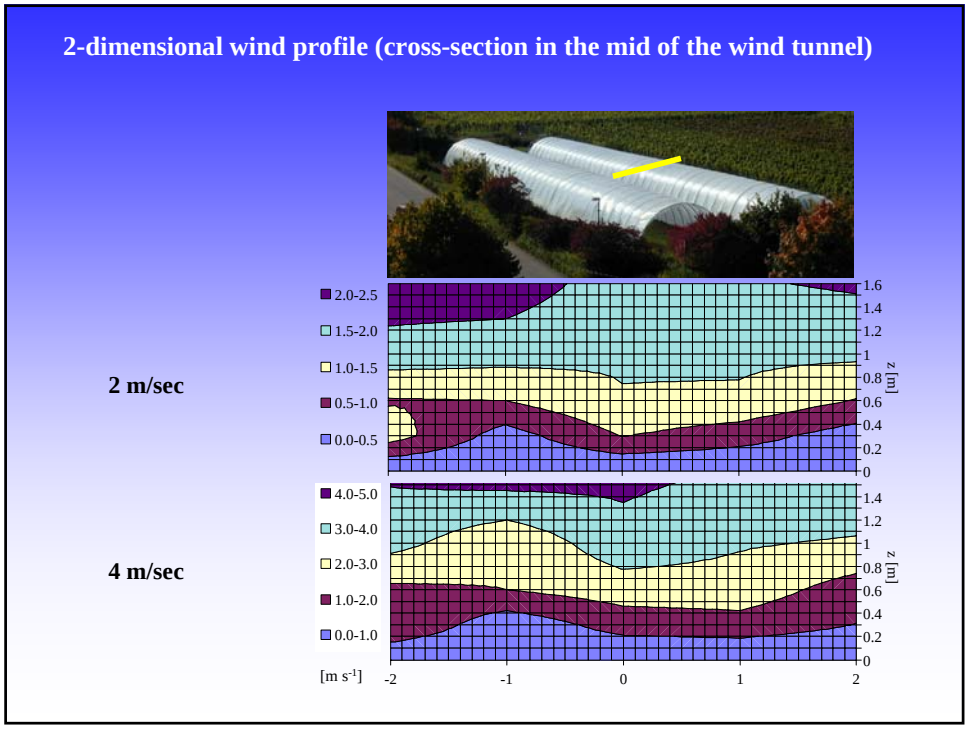




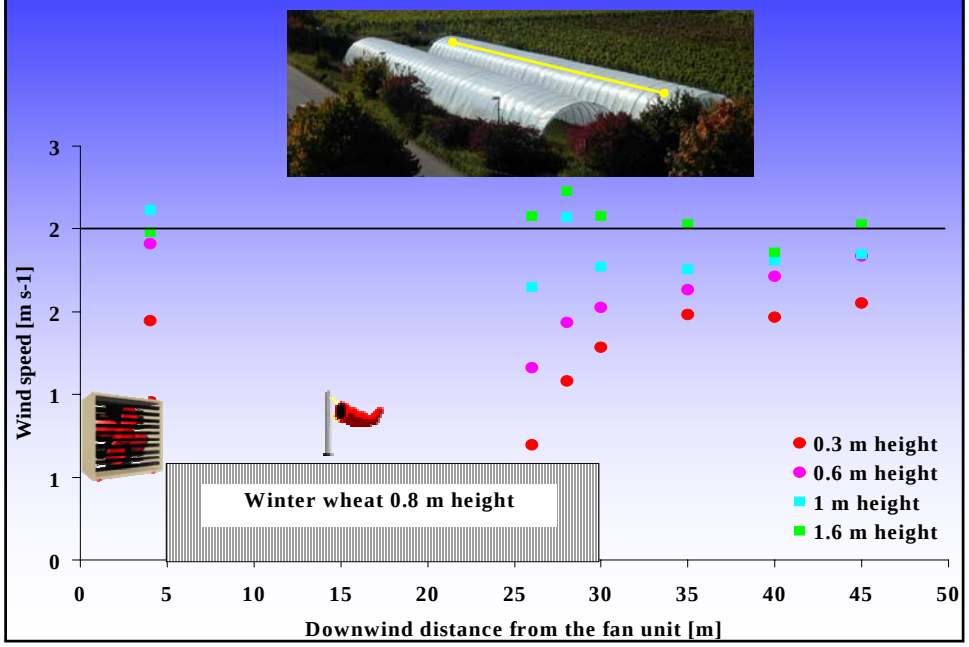


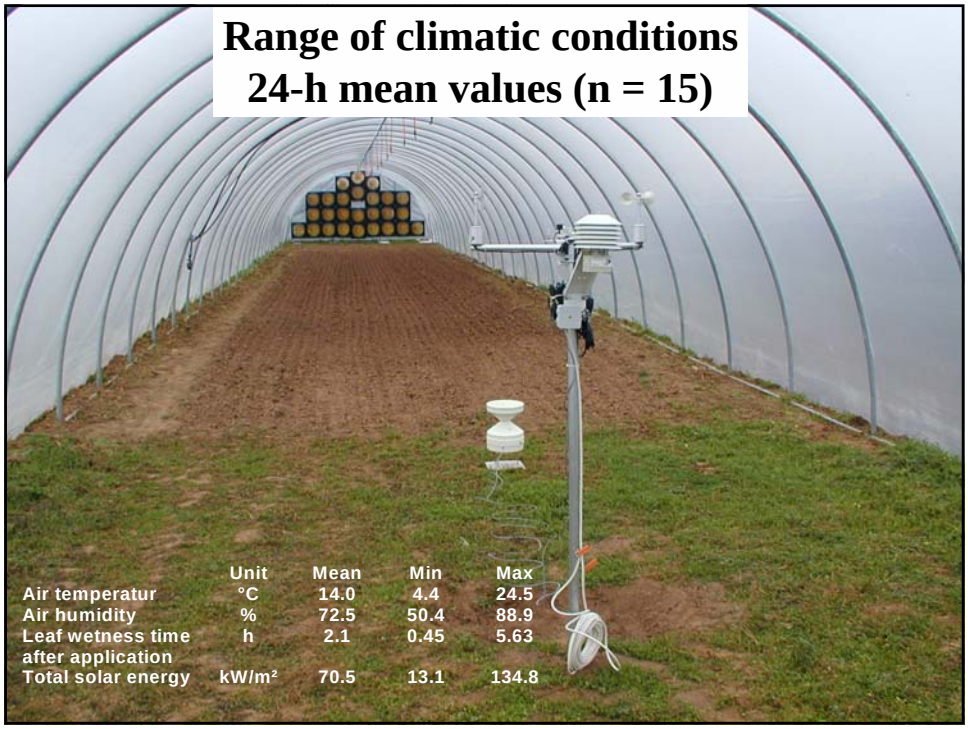


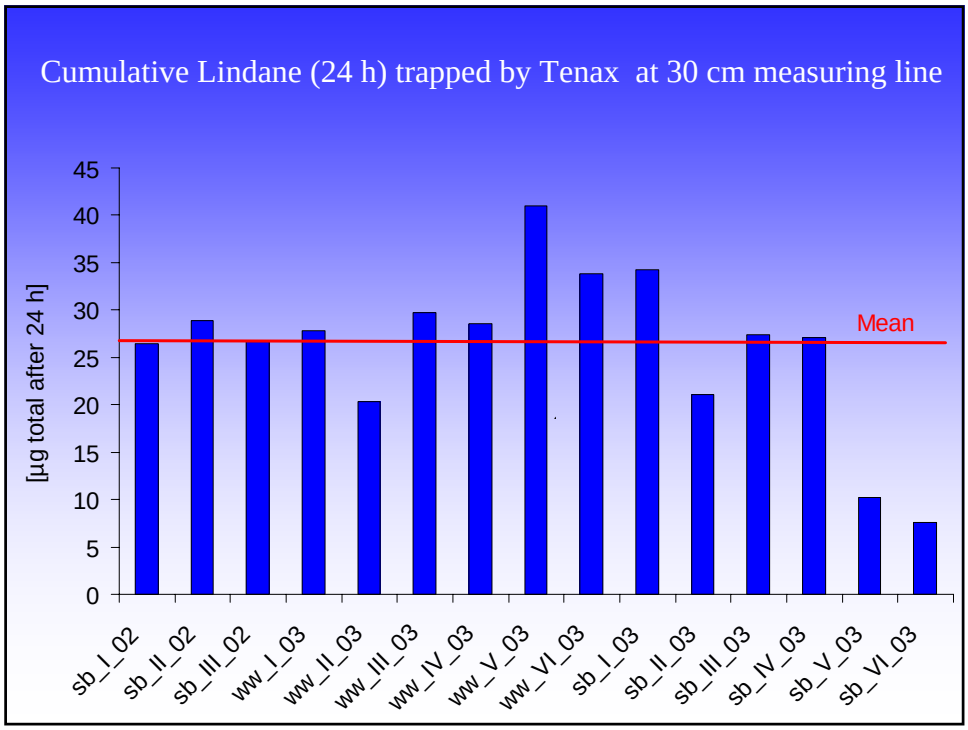
2-dimensional wind profile (cross-section in the mid of the wind tunnel)

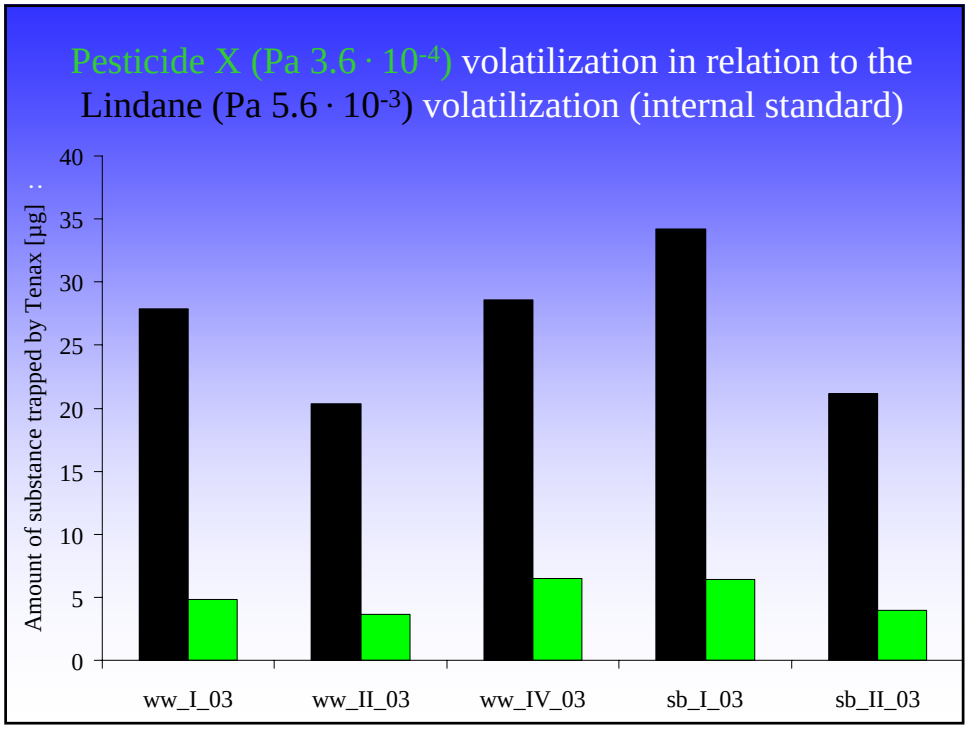


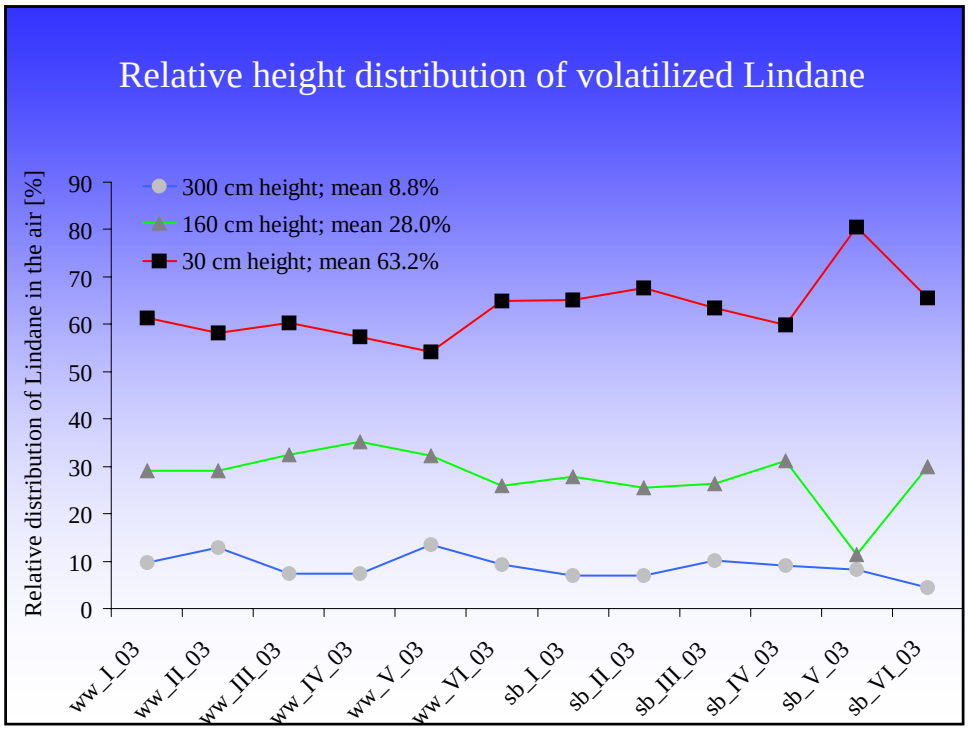
2-dimensional wind profile (cross-section along the wind tunnel)



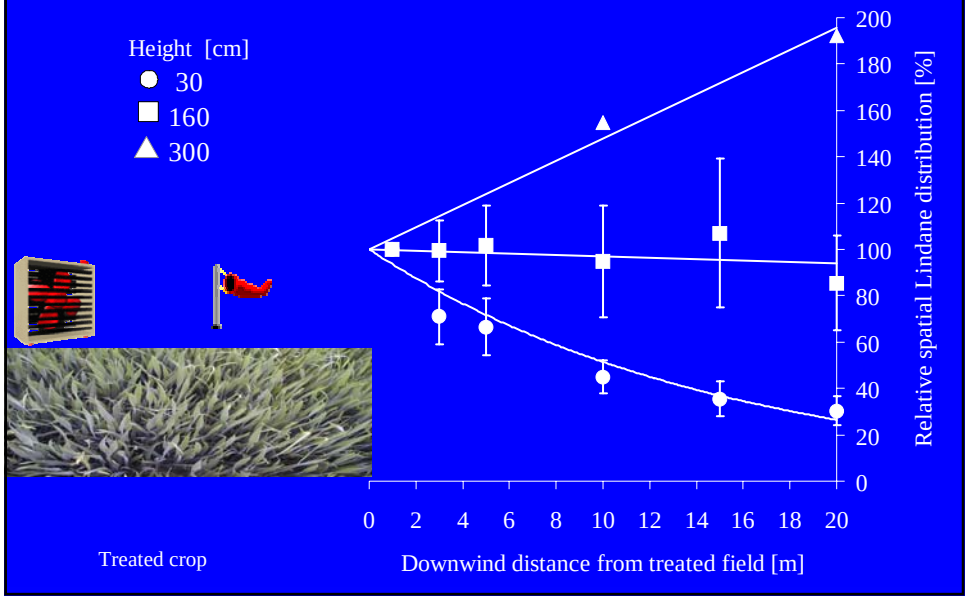

Range of climatic conditions
24-h mean values (n = 15)
Unit Mean Min Max
Air temperatur °C 14.0 4.4 24.5
Air humidity % 72.5 50.4 88.9
Leaf wetness time h 2.1 0.45 5.63
after application
Total solar energy kW/m² 70.5 13.1 134.8


Cumulative Lindane (24 h) trapped by Tenax at 30 cm measuring line
[µg total after 24 h]
45
40
35
30
25
20
15
10
5
0
Mean
sb_I_02
sb_II_02
sb_III_02
ww_I_03
ww_II_03
ww_III_03
ww_IV_03
ww_V_03
ww_VI_03
sb_I_03
sb_II_03
sb_III_03
sb_IV_03
sb_V_03
sb_VI_03

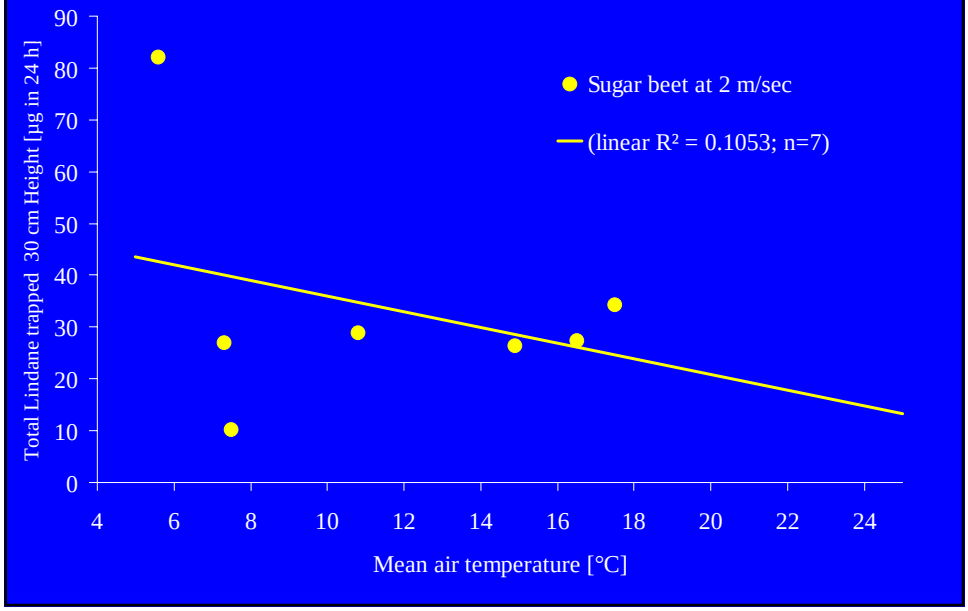

Pesticide X (Pa 3.6 · 10-4) volatilization in relation to the
Lindane (Pa 5.6 · 10-3) volatilization (internal standard)
Amount of substance trapped by Tenax [µg]
40
35
30
25
20
15
10
5
0
ww_I_03
ww_II_03
ww_IV_03
sb_I_03
sb_II_03


Relative height distribution of volatilized Lindane
Relative distribution of Lindane in the air [%]
300 cm height; mean 8.8%
160 cm height; mean 28.0%
30 cm height; mean 63.2%
90
80
70
60
50
40
30
20
10
0
ww_I_03
ww_II_03
ww_III_03
ww_IV_03
ww_V_03
ww_VI_03
sb_I_03
sb_II_03
sb_III_03
sb_IV_03
sb_V_03
sb_VI_03

Spatial distribution of volatilised Lindane



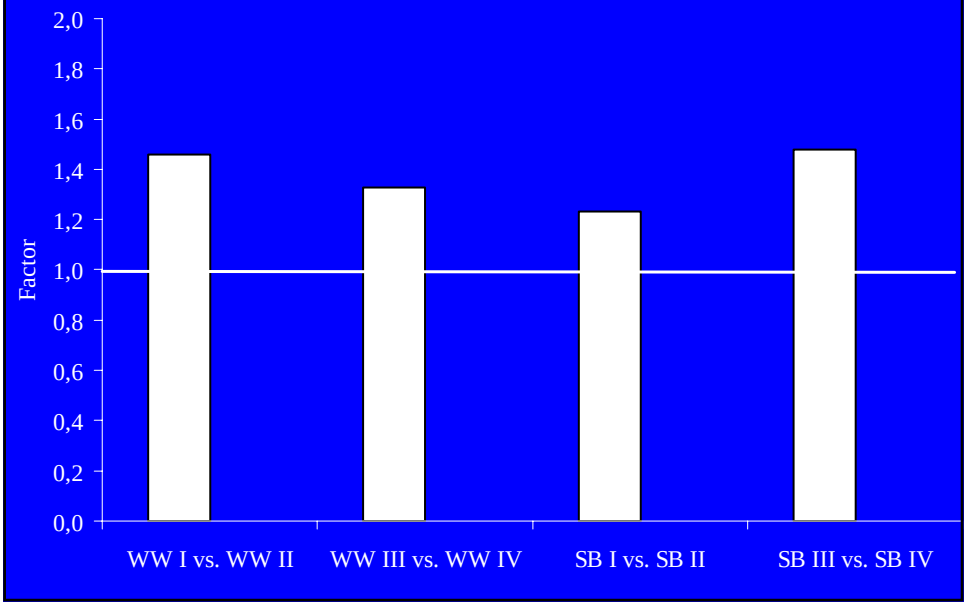
Temperature dependency of Lindane volatilisation

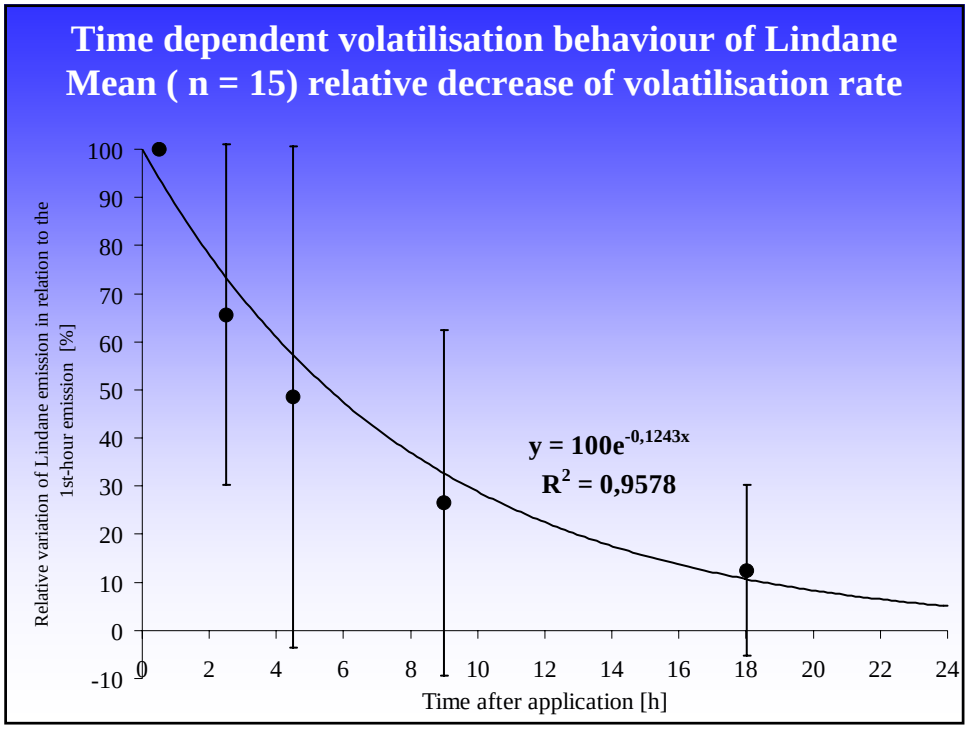


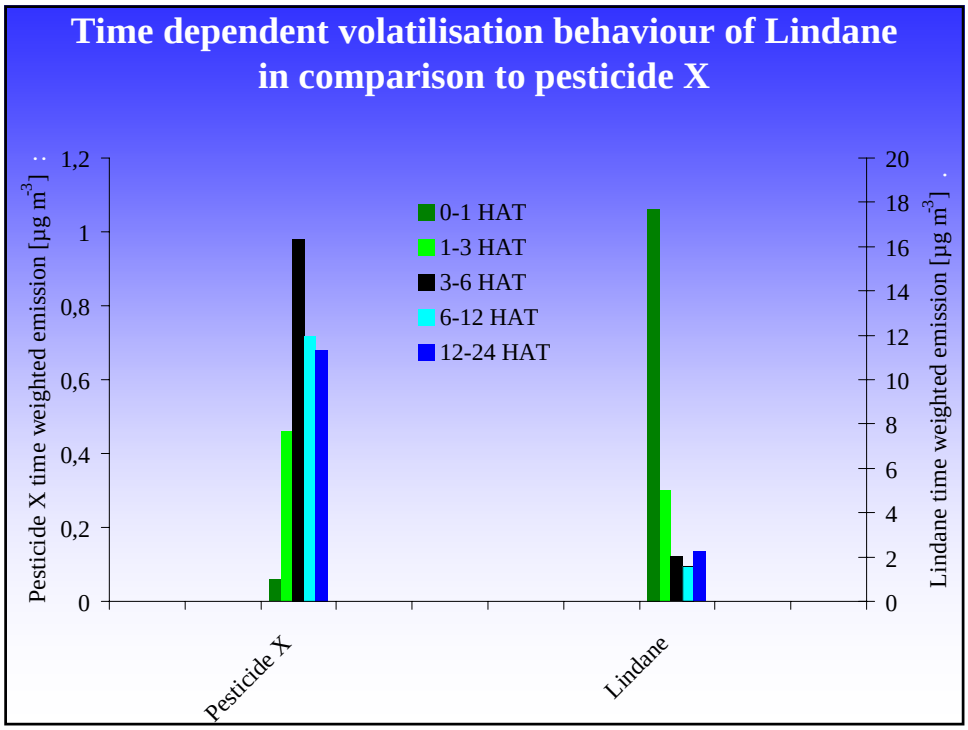
Temperature and crop dependency of Lindane volatilisation (independent t-tests at 95%-level)

	Sugar beet (n=3) 2 m/sec 14.9 °C	Winter wheat (n=3) 2 m/sec 16.2 °C
Sugar beet (n=4) 2 m/sec 6.8 °C	Non-significant	
Sugar beet (n=3) 2 m/sec 16.3 °C		Non-significant

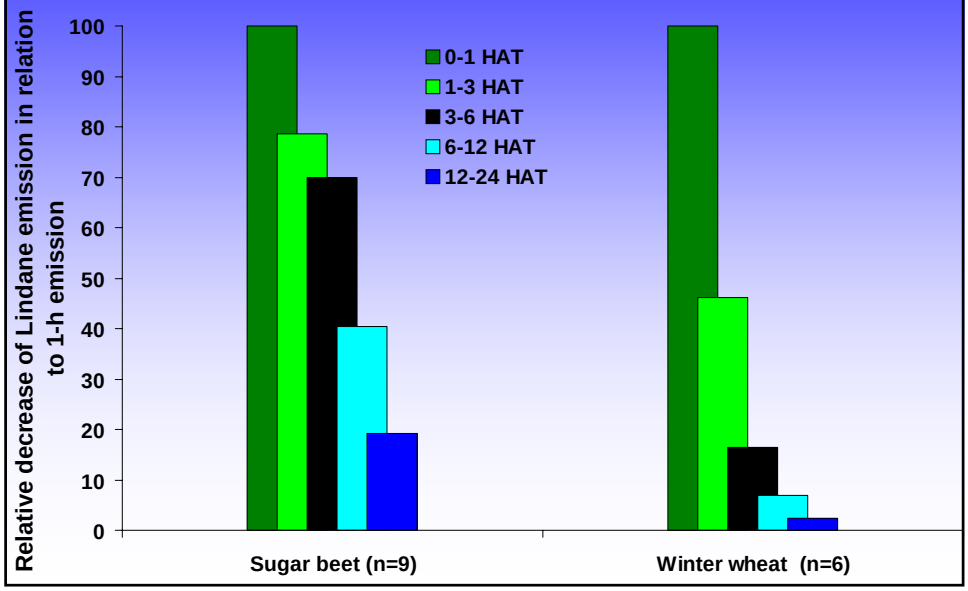
Wind speed dependency of Lindane volatilisation




Time dependent volatilisation behaviour of Lindane
Mean (n = 15) relative decrease of volatilisation rate
Relative variation of Lindane emission in relation to the 1st-hour emission [%]
100
90
80
70
60
50
40
30
20
10
0
-10
0
2
4
6
8
10
12
14
16
18
20
22
24
Time after application [h]
y = 100e-0,1243x
R2 = 0,9578


Time dependent volatilisation behaviour of Lindane
in comparison to pesticide X
Pesticide X time weighted emission [µg m-3]
1,2
1
0,8
0,6
0,4
0,2
0
0-1 HAT
1-3 HAT
3-6 HAT
6-12 HAT
12-24 HAT
20
18
16
14
12
10
8
6
4
2
0
Lindane time weighted emission [µg m-3]
Pesticide X
Lindane

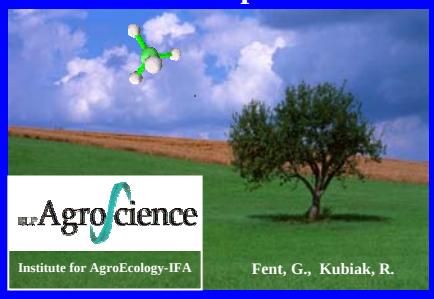
Time dependent volatilisation behaviour of Lindane as a function of crop



Summary and "Take Home Messages"

- An semi outdoor wind tunnel test system was described filling the gab between laboratory- and field volatilisation studies
- Volatilisation potential of pesticides with unknown emission behaviour can be classified by simultaneously applied Lindane as internal standard
- Short range dispersion of volatilized Lindane downwind from the edge of the field was characterized
- Volatilisation of Lindane was no function of temperature (range 6° - 18 ° C)
- Duplication of wind speed from 2 m/sec to 4 m/sec increased Lindane volatilisation by a mean factor of about 1.4
- With few exceptions the maximum volatilisation rates were observed within the 1st hour after application and significantly decreased in the following to about 10% in the 12-24 h period in relation to the 1st-hour rate
- Amount of volatilization was not crop specific but emission as a function of time after treatment was crop and pesticide specific

Fate and transport in air



Thank you for your attention !