Development of anaerobic soil disinfestation

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Presentation anaerobic soil disinfestation (ASD)

- Introduction ASD
- Method
- Process
- Efficacy
- Profitability
- Research topics

Introduction ASD

- Intensive cropping increases soilborne diseases
- Soil disinfestation
    - ASD non-chemical method

- Purpose: killing of soil pathogens and pests by anaerobic decomposition of green (rapidly decomposible) organic material in soil

Mode of action

- depletion of oxygen caused by rapidly decomposing organic material under gastight film.
- toxic compounds are formed; gases, fatty acids

these compounds and anaerobic conditions eliminate pathogenic fungi, bacteria and nematodes

Anaerobic soil disinfestation in general

- Acquisition or growth of 40 tons of green manure (e.g. grass tops) per ha
- Incorporation of organic material into furrow of 30-40 cm
- Light compaction of the top soil
- Irrigation of the soil
- Covering the soil with an oxygen impermeable plastic
- At least six weeks of disinfestation under warm conditions

ASD 1 Freshly cut green manure

ASD 2 Incorporation of green manure

ASD 3 Compacting soil with roller

ASD 5 Laying and bonding plastic film with glue

Process of ASD

- **Oxygen depletion to < 1% within one day**
  - Redox potential decreases:+ 800 to - 400 mV.
  - Reduction of oxygen, nitrate, manganese, iron, sulfate

- **Fermentation compounds are produced**
  - Greenhouse gases: methane, carbon dioxide, nitrous oxide and ammonia
  - Hydrogen sulfide
  - Fatty acids
  - Other (unknown) compounds

Efficacy ASD

- Pathogenic fungi
  - *Fusarium oxysporum* ; moderate to high
    - **Higher asparagus yield up to six years after ASD**
  - *Verticillium dahliae* ; good to high
    - **Efficacy remained for four years in trees**
  - *Rhizoctonia* spp.; AG dependent
  - *Sclerotinia* spp.; species dependent

Efficacy ASD

■ Parasitic nematodes

- *Pratylenchus penetrans* ; high
- *Meloidogyne* spp. ; high
- *Globodera pallida* ; moderate to good
- *Ditylenchus* spp. ; good
- *Trichodorus* spp. ; high
  - surviving nematodes may transmit tobacco rattle virus; potato damage

Efficacy ASD

- **Pathogenic bacteria**
  - *Ralstonia solanacearum* ; good

- **Weeds**
  - Seed weeds: irregular efficacy
    - Seeds in incorporated green manure; negative efficacy
  - Root stock weeds: high

Profitability ASD in the Netherlands

- Costs ± €4000/ha

- Profitable only in high cash crops:
  - asparagus production fields
  - strawberry runners production fields
  - tree nurseries

Research topics

- **Fundamental information needed for <u>wide scale application</u>**
  - Which compounds are responsible for efficacy
  - At what concentrations
  - For what period anaerobic conditions are necessary
  - Influence of soil temperature, pH, soil humidity
  - Influence of soil micro flora
  - Influence of fertilizer status
  - Most suitable type of organic matter; C:N ratio

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Research 2009 – 2011 'Development of ASD'

- Funded by Dutch Ministry of Agriculture, Nature and Food Quality

- Project group
  - Willemien Runia, Leendert Molendijk   PPO-AGV
  - Corrie Schomaker   PRI
  - Herman Feil, Henk Meints   Thatchtec (TDI)

- Consultant
  - Gera van Os   PPO-BBF

- Partners
  - Pim Paternotte, Daniël Ludeking   WUR Horticulture

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Research 2009 – 2011 'Development of ASD'

- Aim: establishing mode of action of ASD

- Approach: ASD with defined fermentation products **under controlled conditions**
  - Varying in C:N ratio

- Assessments on: Oxygen consumption and production of greenhouse gases and fatty acids in relation to
  - Efficacy against soilborne pathogens and pests
  - Effect on fertilizer status and plant growth
  - Effect on soil microbial status

Trial 2009 under controlled conditions

- **Sealed containers at 16°C**
  - 8 fermentation products; a.o. varying in C:N ratio
  - Referent grass (anaerobic conditions + organic material)
  - Referent inundation (anaerobic conditions - organic material)
  - Untreated soil (container with lid)
  - Untreated soil (container without lid, natural decline)

- **Objects:**
  - 3 dosages
  - 3 exposure times; 2, 4 and 8 weeks
  - 2 soil types; clay and sand

Trial 2009

- Target organisms:
  - *Pratylenchus penetrans*   juveniles
  - *Globodera pallida*   cysts
  - *Verticillium dahliae*   microsclerotia

  Artificially applied to containers (8 liters of soil)

Incorporation of soil

Filling containers with soil

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Pratylenchus juveniles

Verticillium microsclerotia

Globodera cysts

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After incorporation of product and inoculation of organisms

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Assessments for 8 weeks

Hand meter O$_2$, H$_2$S, CH$_4$, NH$_3$

Greenhouse gas meter CH$_4$, NH$_3$, CO$_2$, N$_2$O

|	A	B	C	D	E	F	G	H	I	J	K
1	Onderzoeker			waarneming weer							
2	reg.nr.			tijdstip				emmer grootte	aankruisen		
3	proj.nr			bewolking				10,8 liter			
4	prot.nr			zon				26 liter			
5	datum			windrichting				33 liter			
6	naam			windsnelheid				67 liter			
7				gewas vochtig							
8				opmerkingen				bkg comm1.SW3			
9											
10			A	B	C	D	E	F			
11	Veldnr-emmernr / datum	tijd	CO2 in ppm	N2O in ppm	NH4 in ppm	CH4 in ppm	nvt	water damp in ppm			
355	Data	Logger:	Measurement	Finished							
356	27										
357	Data	Logger:	Measurement	Started							
358	13		18:25:02	128,000.00000	261.00000	11.40000	370.00000	16.40000			
359	13		18:26:11	128,000.00000	218.00000	11.20000	287.00000	16.20000			
360	Data	Logger:	Measurement	Finished							
361	108										
362	Data	Logger:	Measurement	Started							
363	13		18:28:16	147,000.00000	1,860.00000	38.50000	2,450.00000	16.60000			
364	13		18:29:25	147,000.00000	1,870.00000	38.70000	2,450.00000	16.60000			
365	Data	Logger:	Measurement	Finished							
366	96										
367	Data	Logger:	Measurement	Started							
368	13		18:31:29	174,000.00000	111.00000	23.60000	194.00000	15.90000			
369	13		18:32:38	174,000.00000	98.80000	23.50000	173.00000	15.90000			
370	Data	Logger:	Measurement	Finished							
371	78										
372	Data	Logger:	Measurement	Started							
373	13		18:34:47	123,000.00000	31.50000	8.79000	35.60000	16.20000			
374	13		18:35:56	123,000.00000	30.70000	8.77000	32.30000	15.90000			
375	Data	Logger:	Measurement	Finished							
376	12										
377	Data	Logger:	Measurement	Started							
378	13		18:38:02	61,600.00000	4,370.00000	7.05000	11,600.00000	16.00000			

Results 2009

- Figures: **peak values** of all products $\rightarrow$ efficacy
- One gas/fatty acid per figure; process includes complex of several gases and fatty acids 'simultaneously'
  - **Indications; no conclusions**
- Next step: **C/T values** $\rightarrow$ efficacy
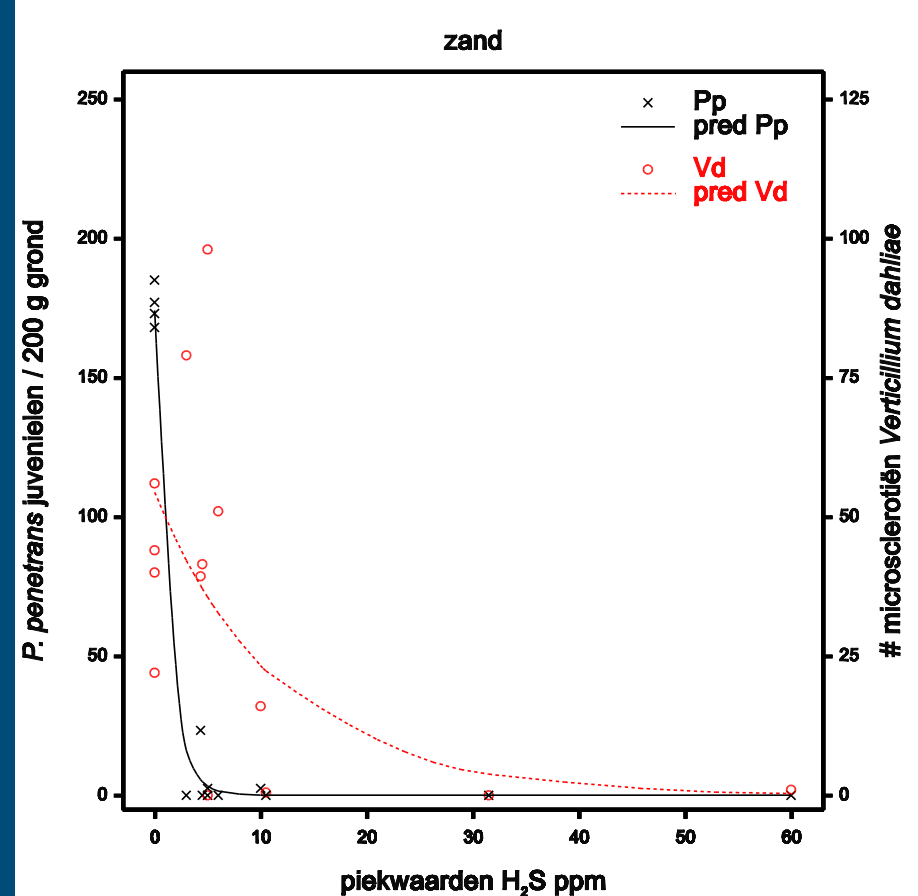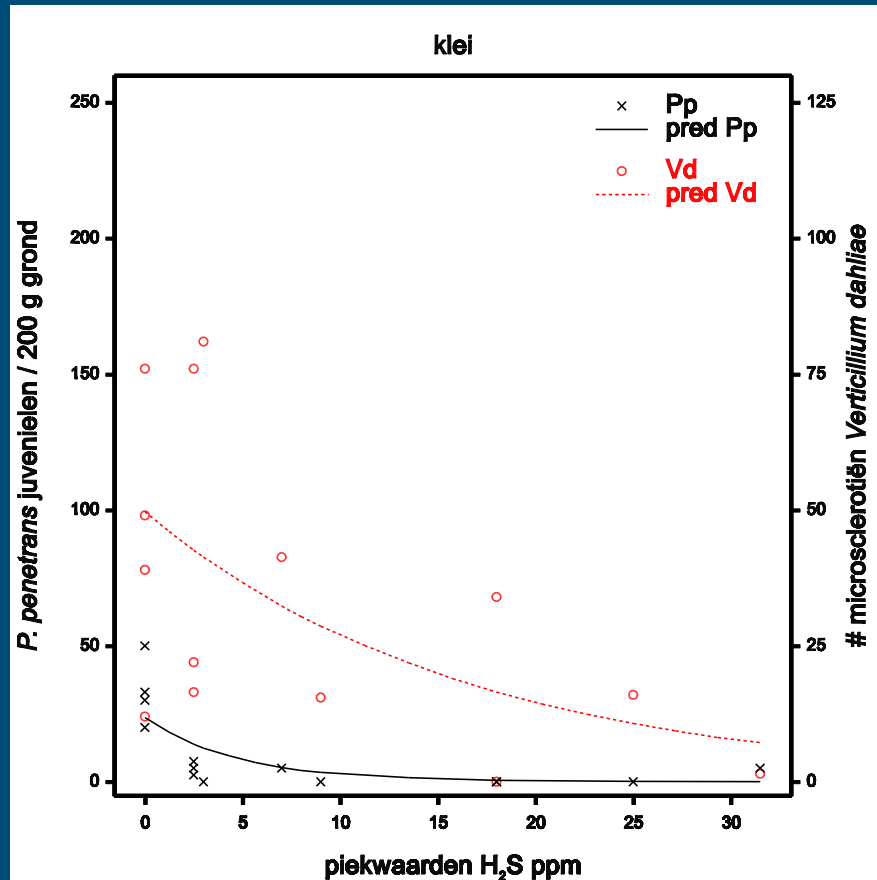- Not all products tested against *V. dahliae*

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O$_2$ – efficacy *Pratylenchus* and *Verticillium*

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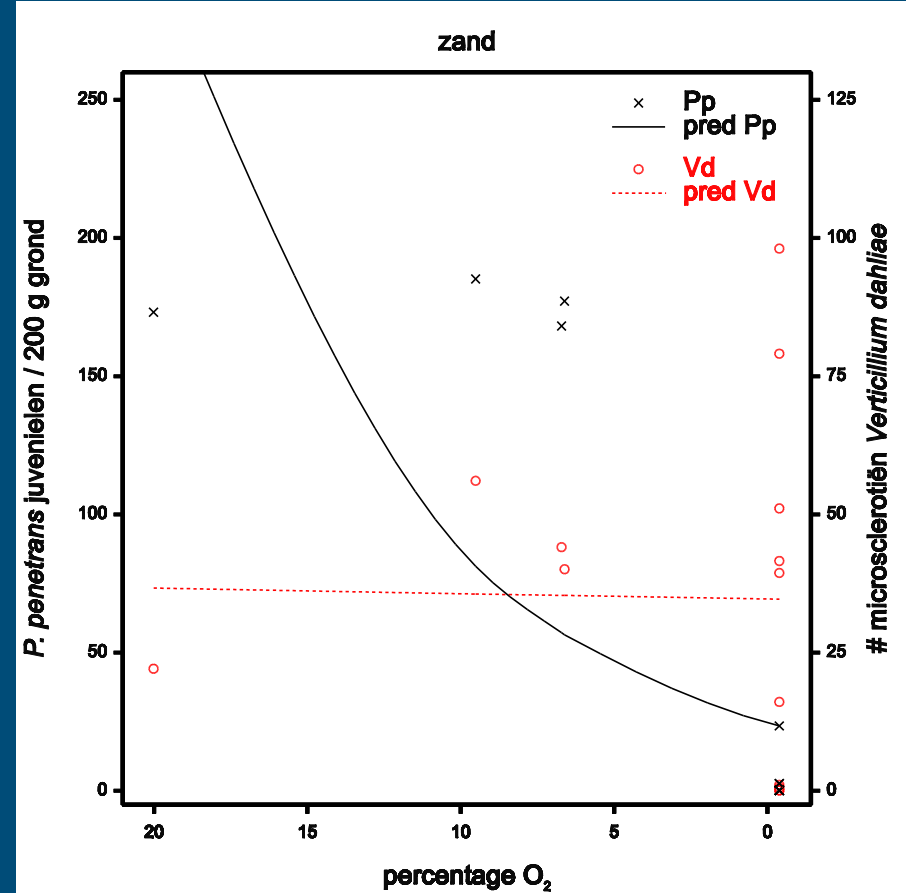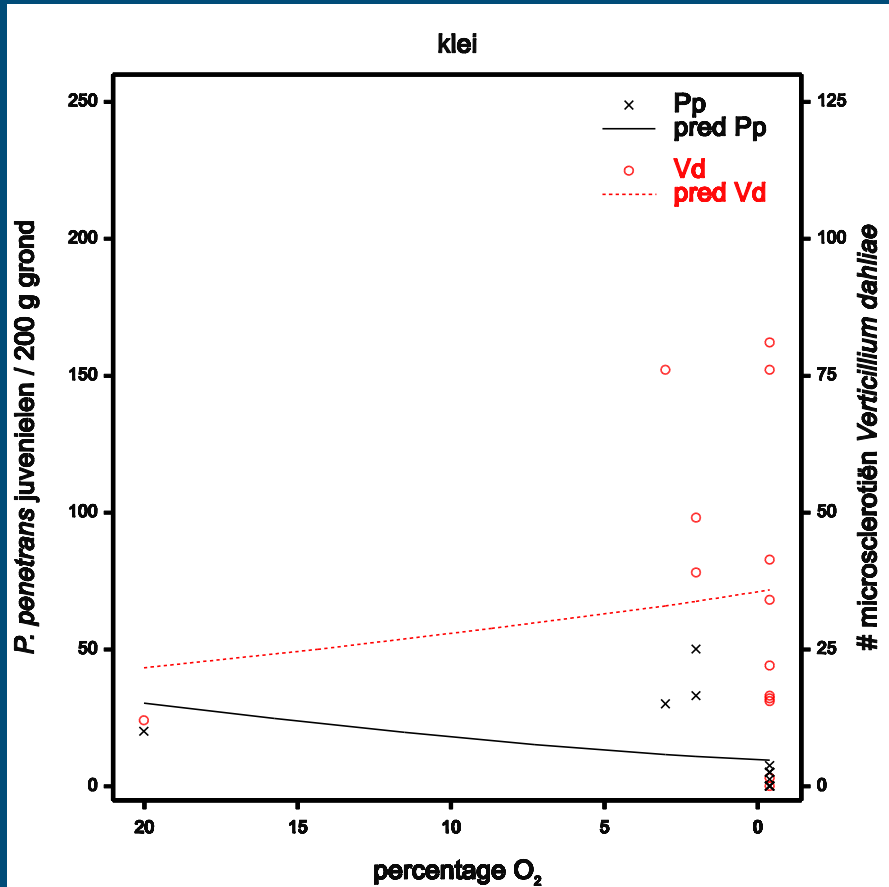
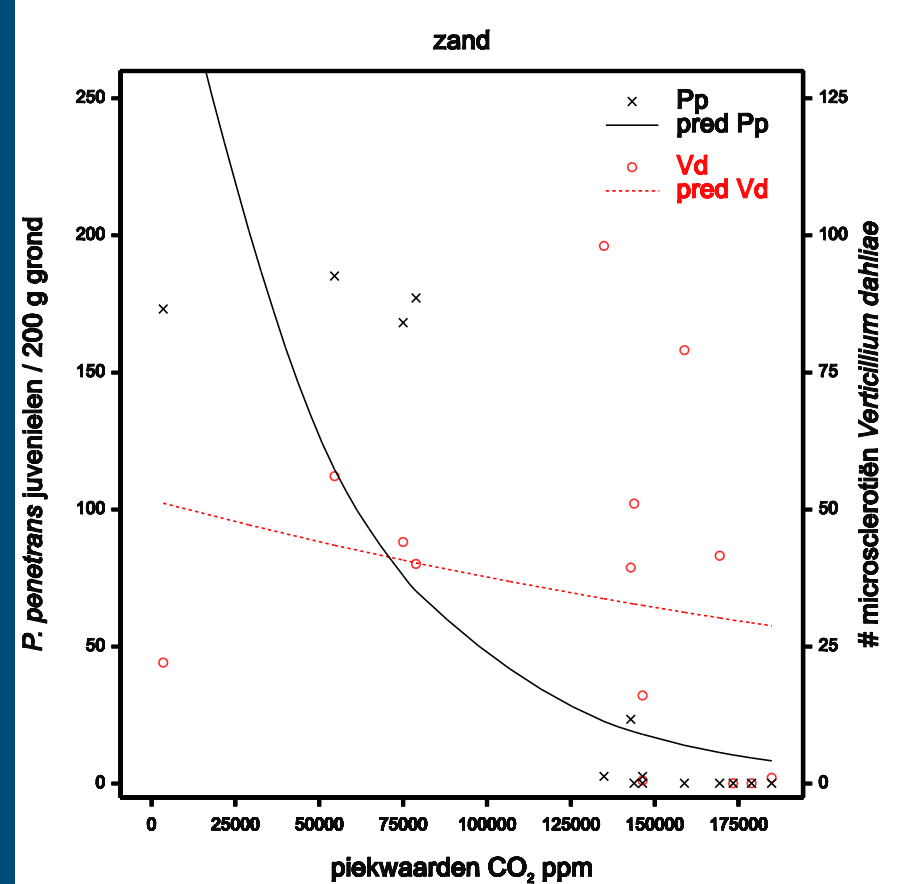# peak values NH$_3$ – efficacy *Pratylenchus* and *Verticillium*
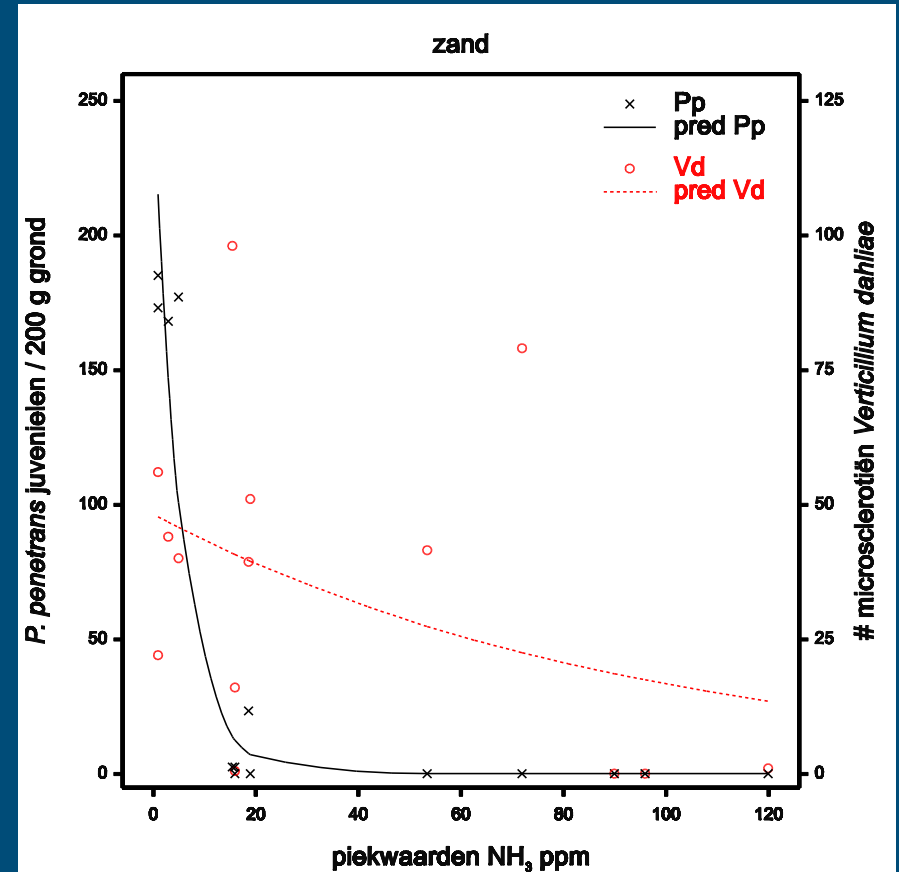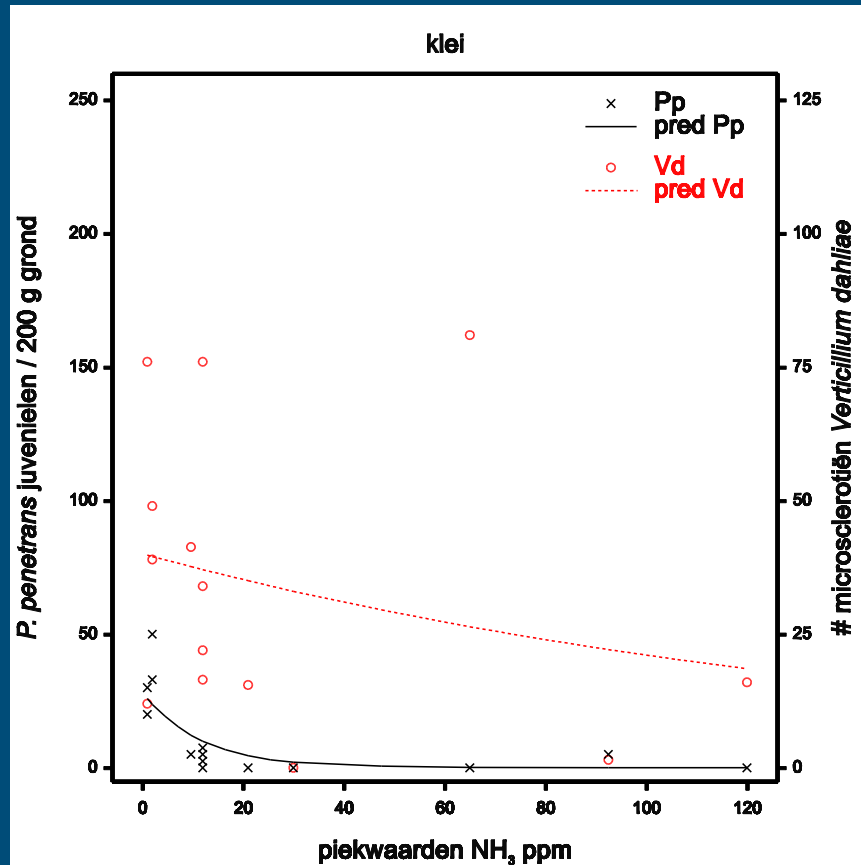
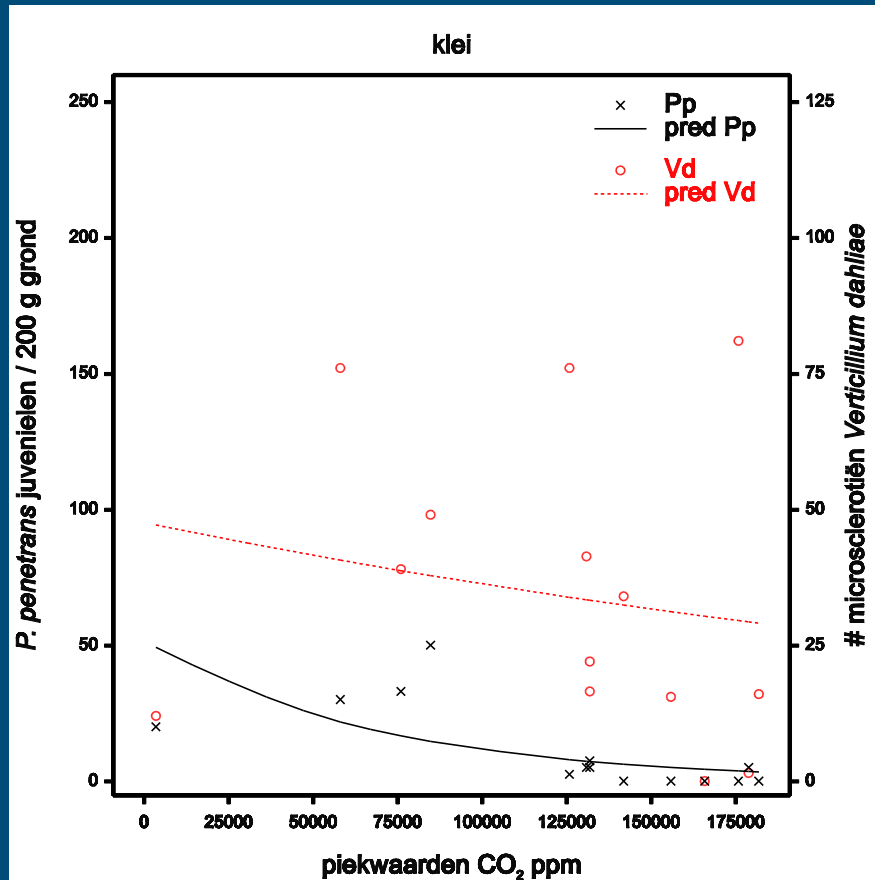# peak values H$_2$S – efficacy *Pratylenchus* en *Verticillium*

peak values N$_2$O – efficacy *Pratylenchus* en *Verticillium*
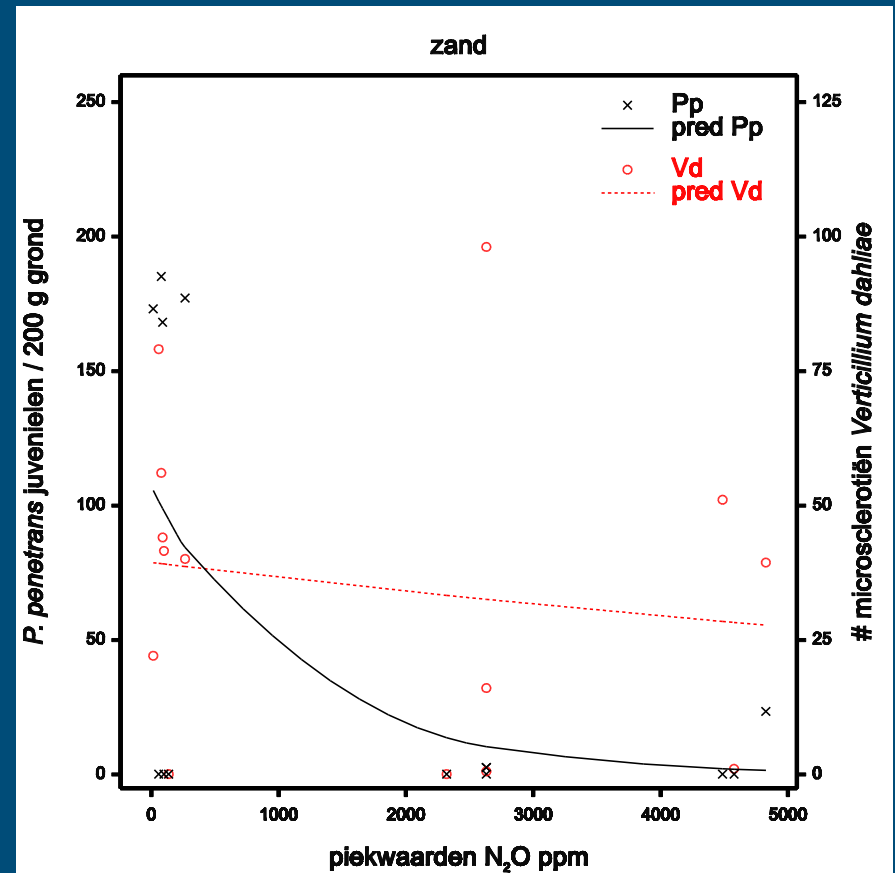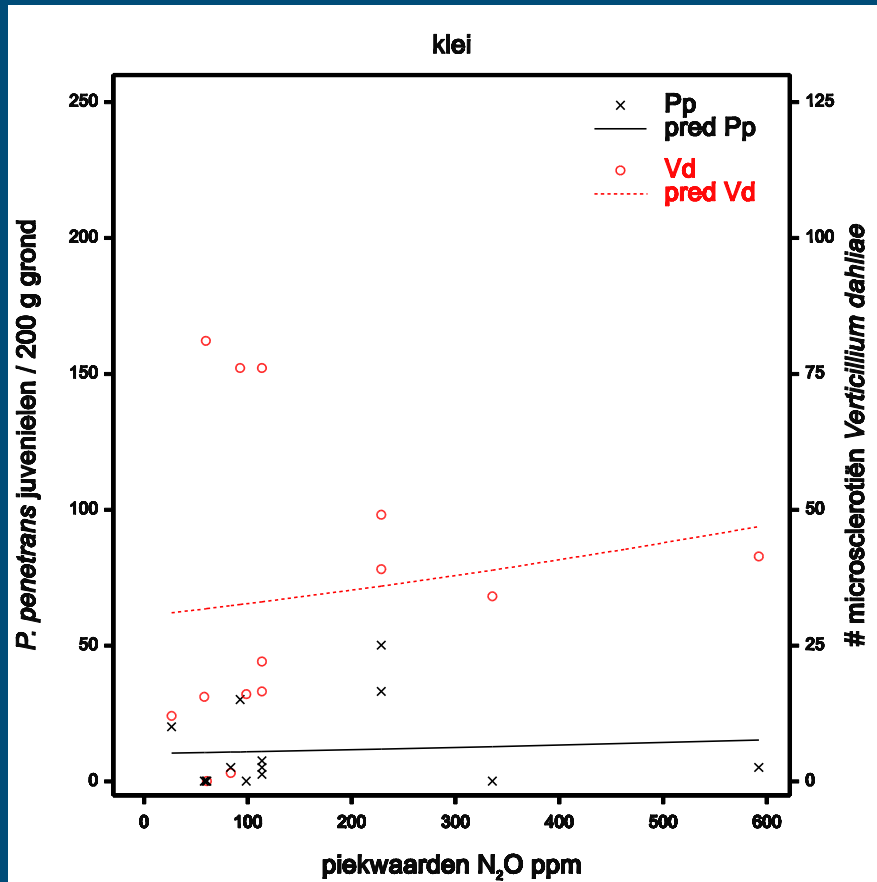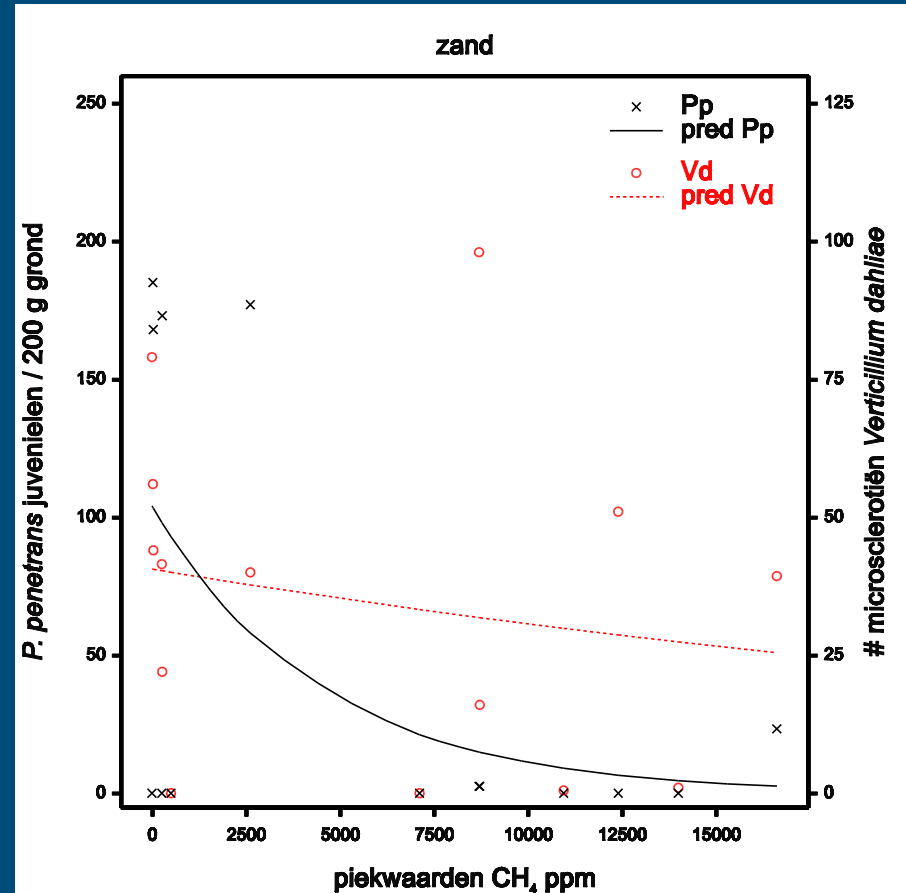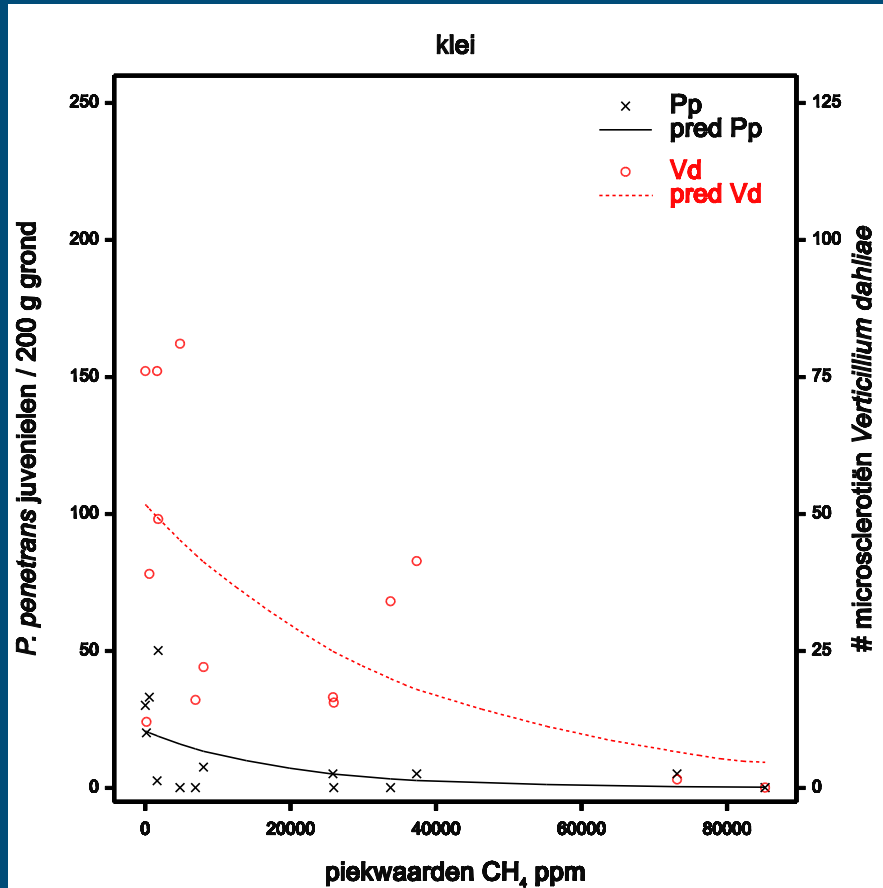
peak values CO$_2$ – efficacy *Pratylenchus* en *Verticillium*

Indications role greenhouse gases

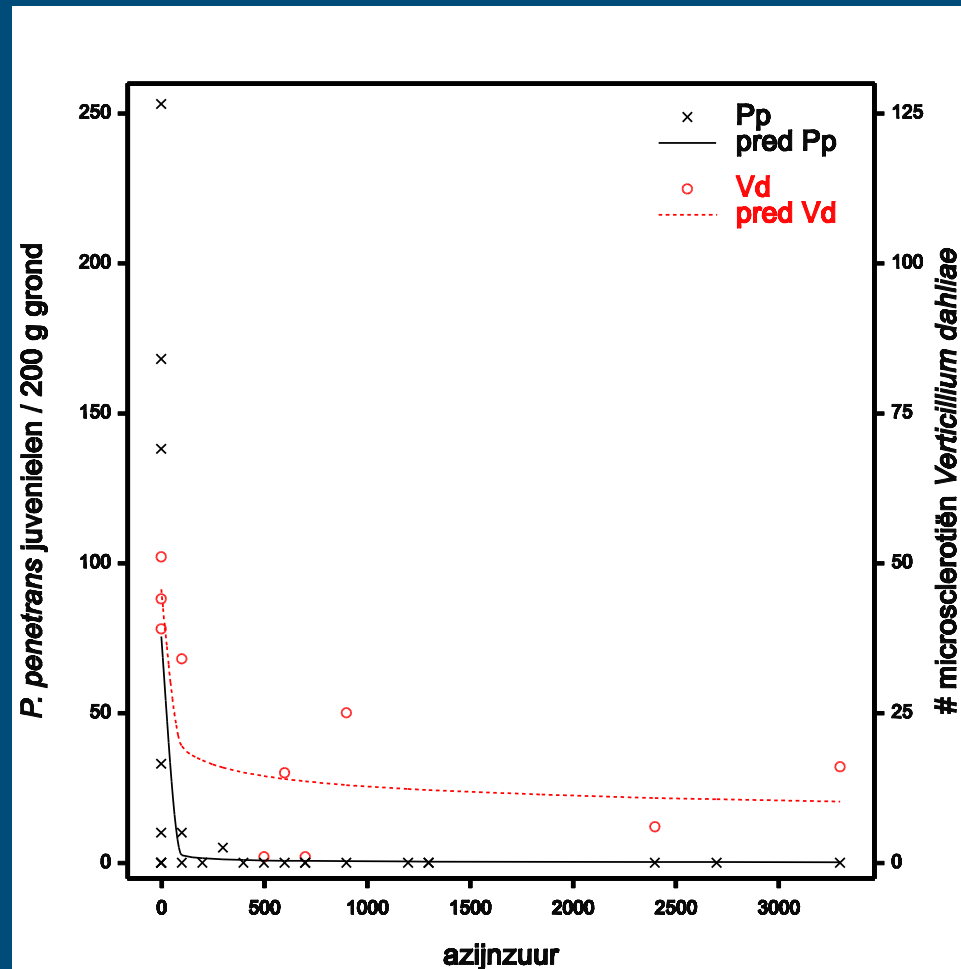| Efficacy	*P. penetrans*	*P. penetrans*	*V. dahliae*	*V. dahliae*
	clay	sand	clay	sand
no O_2	±	±	-	-
NH_3	+	+	±	±
H_2S	+	+	+	+
CH_4	+	±	+	-
CO_2	+	+	-	-
N_2O	±	±	-	-

Fatty acids

- One assessment after 4 weeks exposure time
- peak values unknown
- Fatty acid production during 8 weeks exposure time unknown
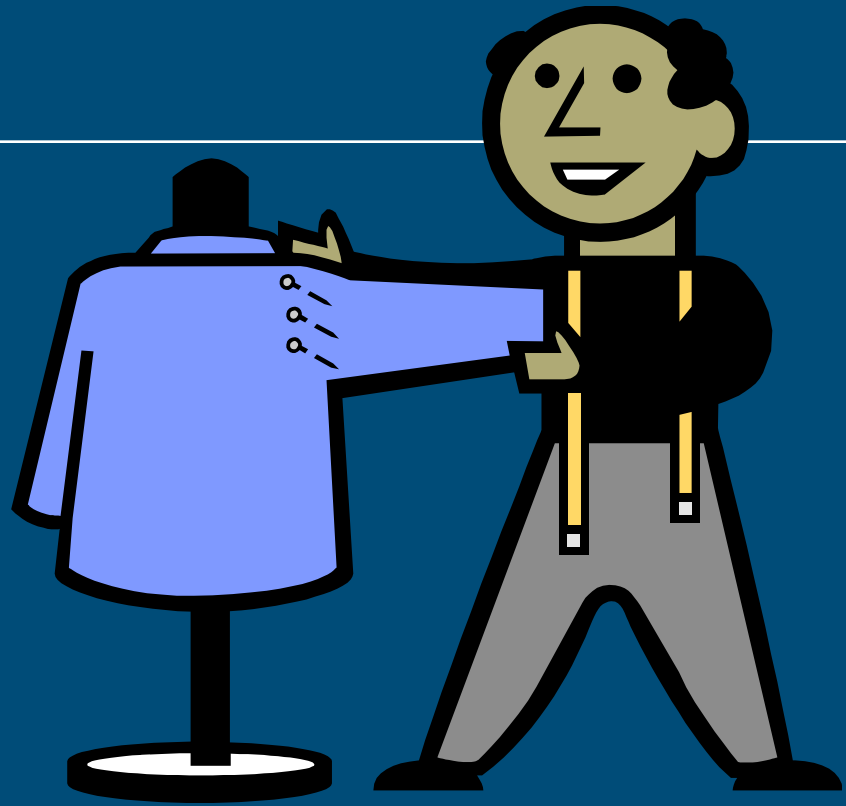- Highest values; acetic acid, butyric acid, propionic acid

Conclusion

- Gases and fatty acids involved in ASD defined
- Role of O_2 defined
- Efficacy fermentation products defined; more effective than grass

- Application of gases and fatty acids separately under controlled conditions can define efficacy of each compound against soilborne pathogens and pests

■Tailor made approach based on knowledge of mechanisms

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