Climate Change in relation to Crop Protection

agriculture, nature
and food quality

Erno Bouma

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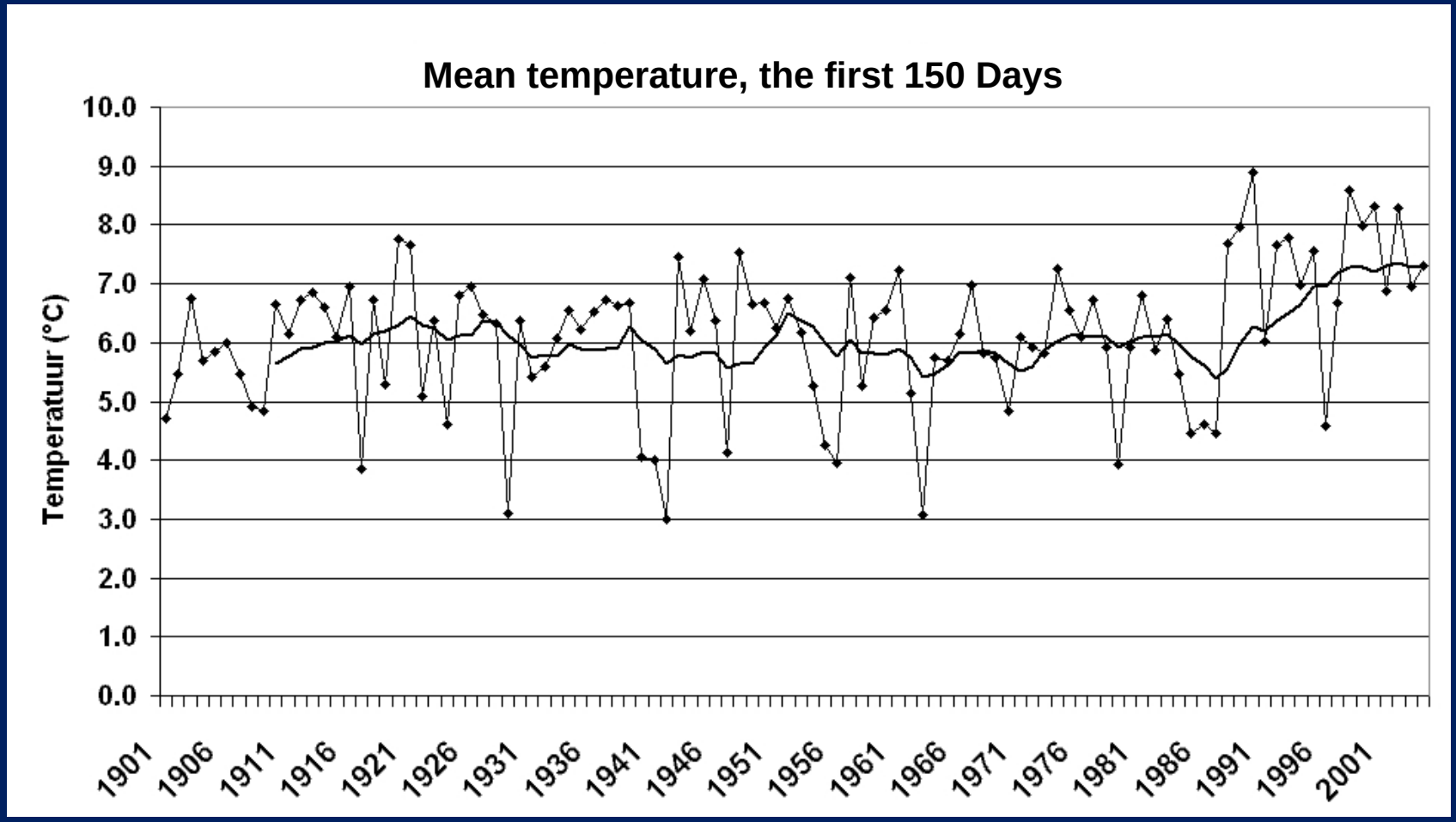
Basic question:

- Does Climate Change have an impact on agriculture and crop protection in the Netherlands in 2050?

Outlook

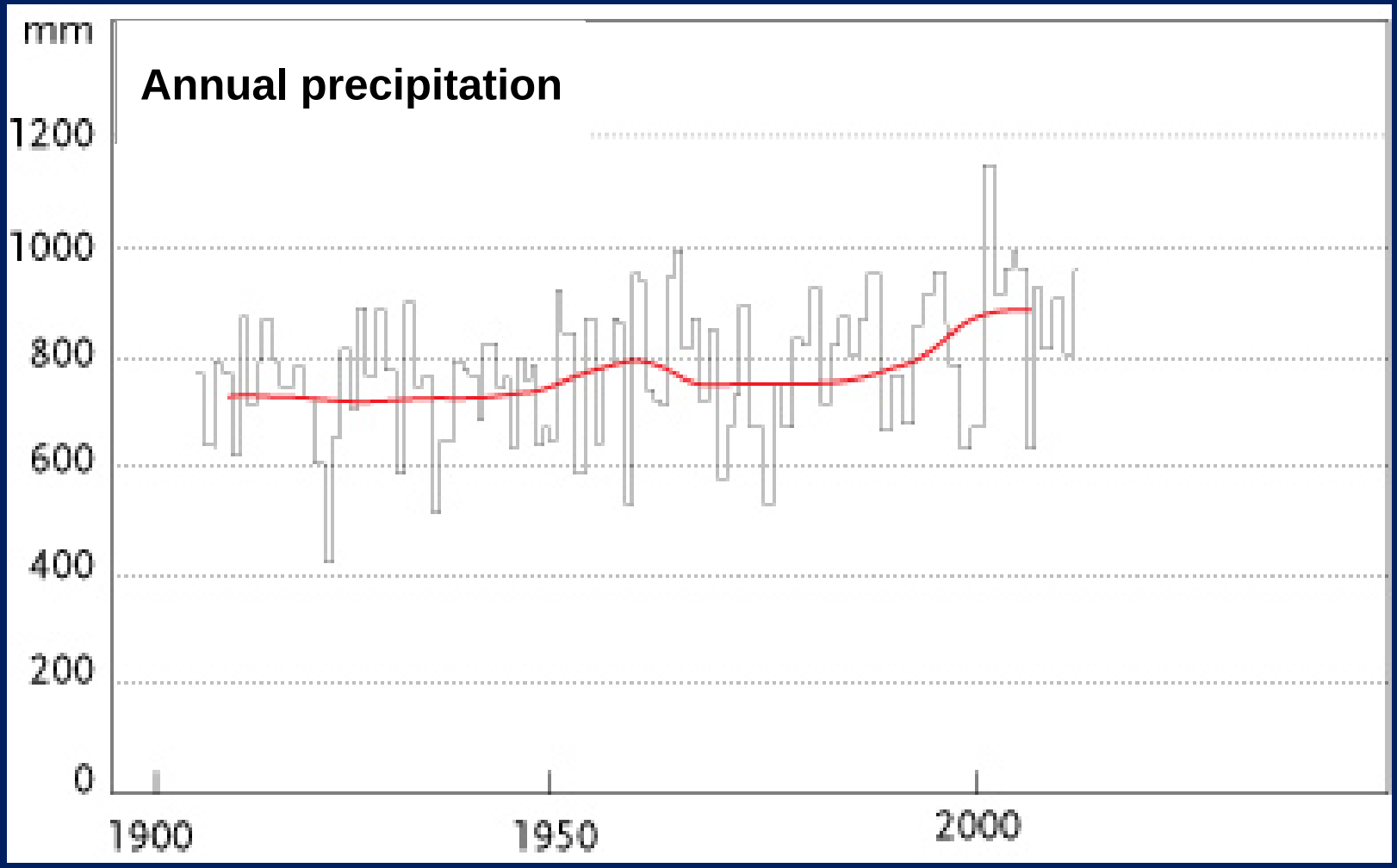
- Change in Temperature and Precipitation pattern
- Impact on agriculture in the Netherlands
  - Impact of greenhouse gases
  - Geographical distribution of pests
  - Effectiveness of management strategies
- Conclusion

Change in Temperature and Precipitation pattern



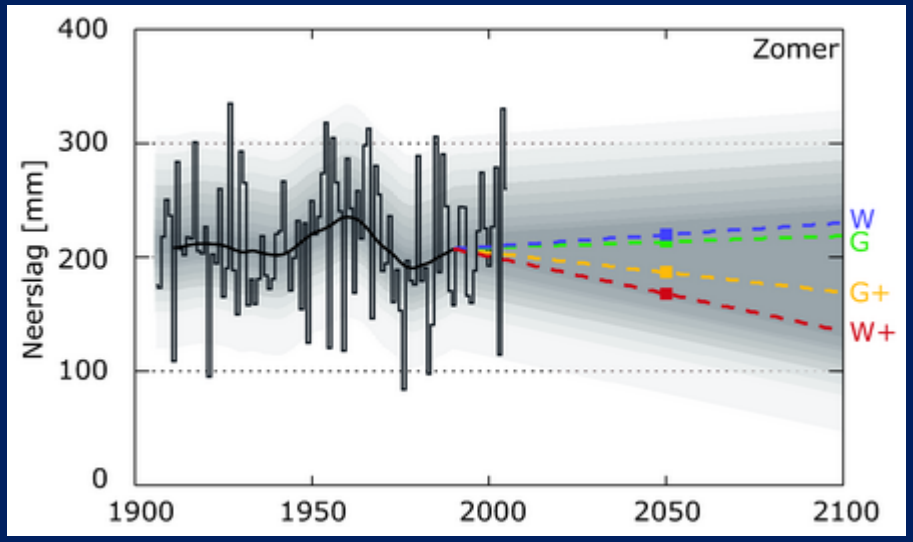
Source: KNMI 2008

Change in Temperature and Precipitation pattern



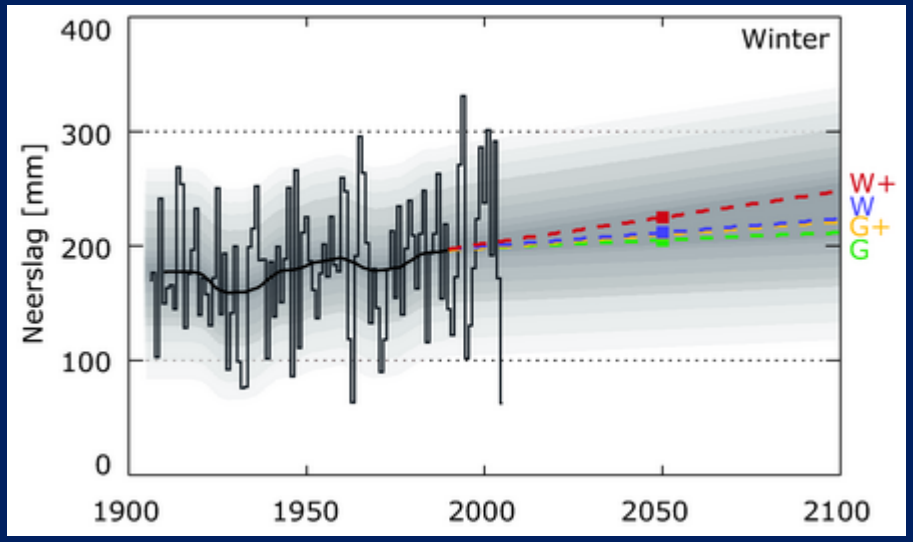
Source: KNMI, 2008

Change in Temperature and Precipitation pattern



Summer

Winter



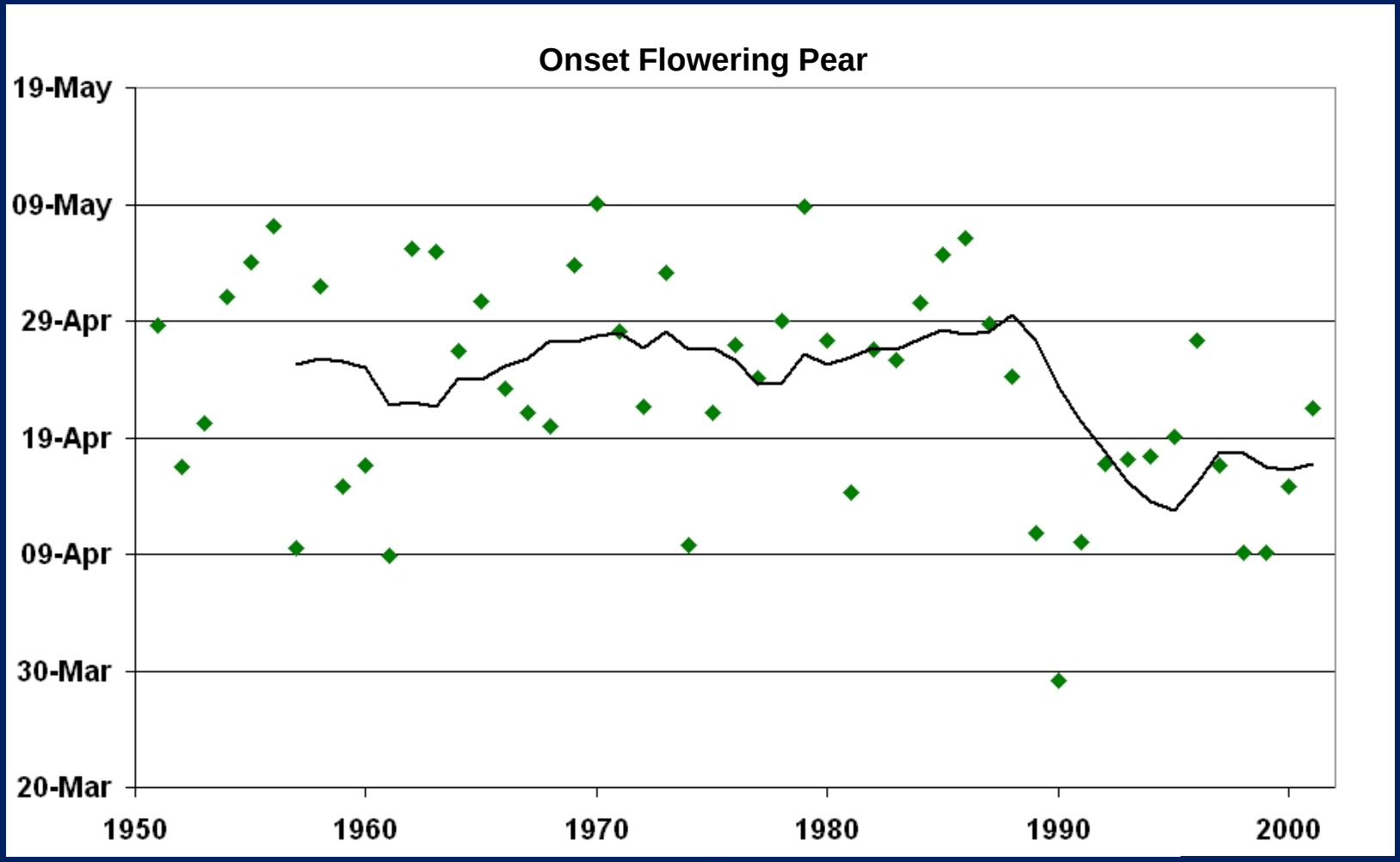
Source: KNMI, 2008

Change in Temperature and Precipitation pattern

- Conclusion
  - Temperature increase of 0.5 – 2°C
  - Mean temperature will rise in the first 150 days
    - Rise of minimum temperature important
  - Increase of total sum precipitation
    - Winter precipitation **+**
    - Spring/Summer precipitation **–**
    - More extreme weather events
    - Drier conditions during growing season

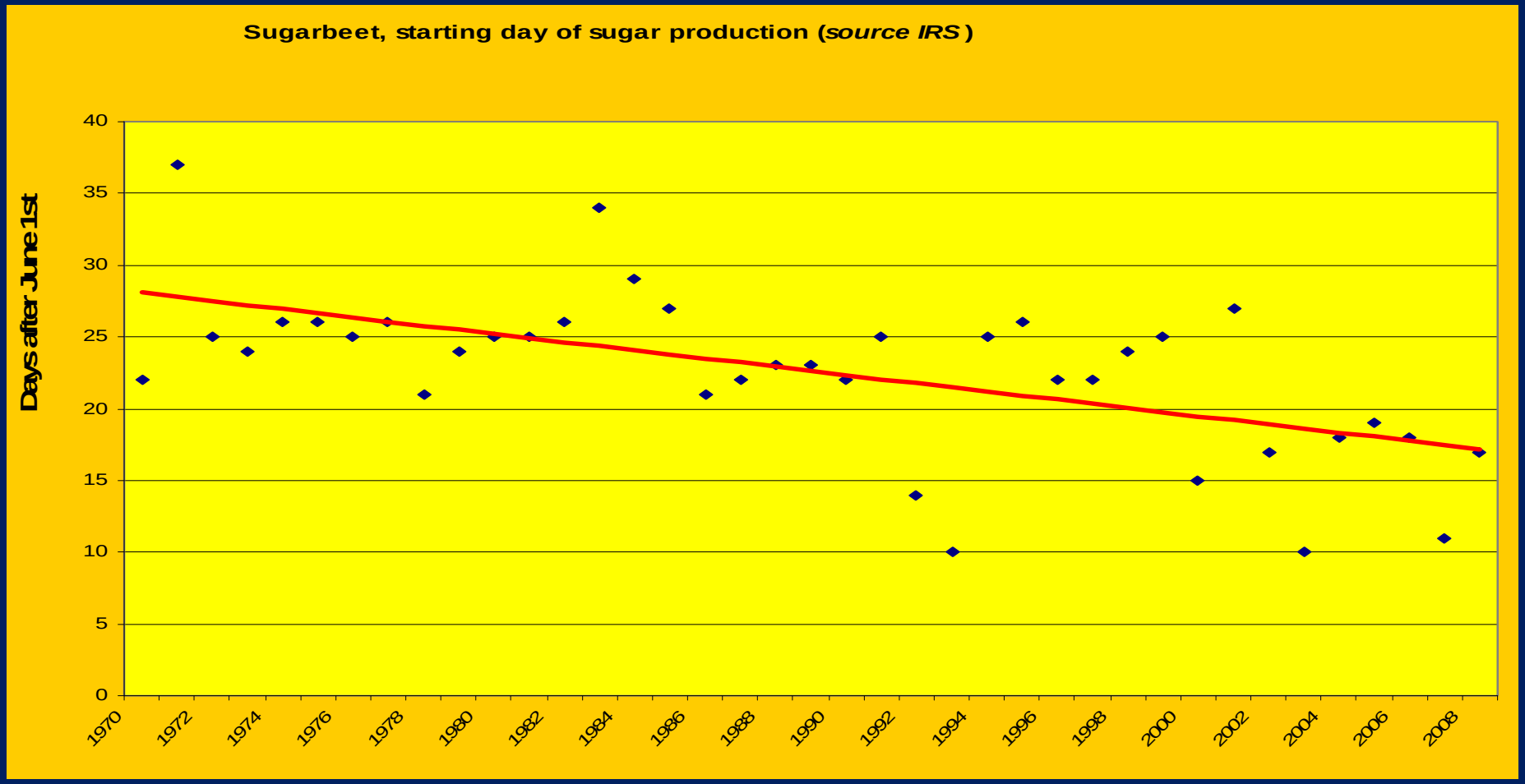
Highlight the first 150 days of the year……

Highlight the first 150 days



Source: van Vliet, 2008

Highlight the first 150 days



Highlight the first 150 days

- Conclusion
  - Vegetative and generative development 10 to 20 days earlier

Impact on agriculture in the Netherlands

Impact on agriculture in the Netherlands

- Higher temperature
- Impact of greenhouse gases
- Geographical distribution of pests
- Effectiveness of management strategies

Erno Bouma, Plant Protection Service, Wageningen

Impact on agriculture in the Netherlands

Higher temperature, impact on Plant Production:

- Length of the growing period will increase
- Problems at the start and at the end of growing period
- Accelerate plant development
- Increase crop water consumption
- Possibility to grow more crops per year

Impact on agriculture in the Netherlands

- Impact of greenhouse gases:
  - Level CO_2 will increase, impact on plant production
  - Relation between higher levels of CO_2 and weed behaviour
  - Damage of troposphere O_3

Impact on agriculture in the Netherlands

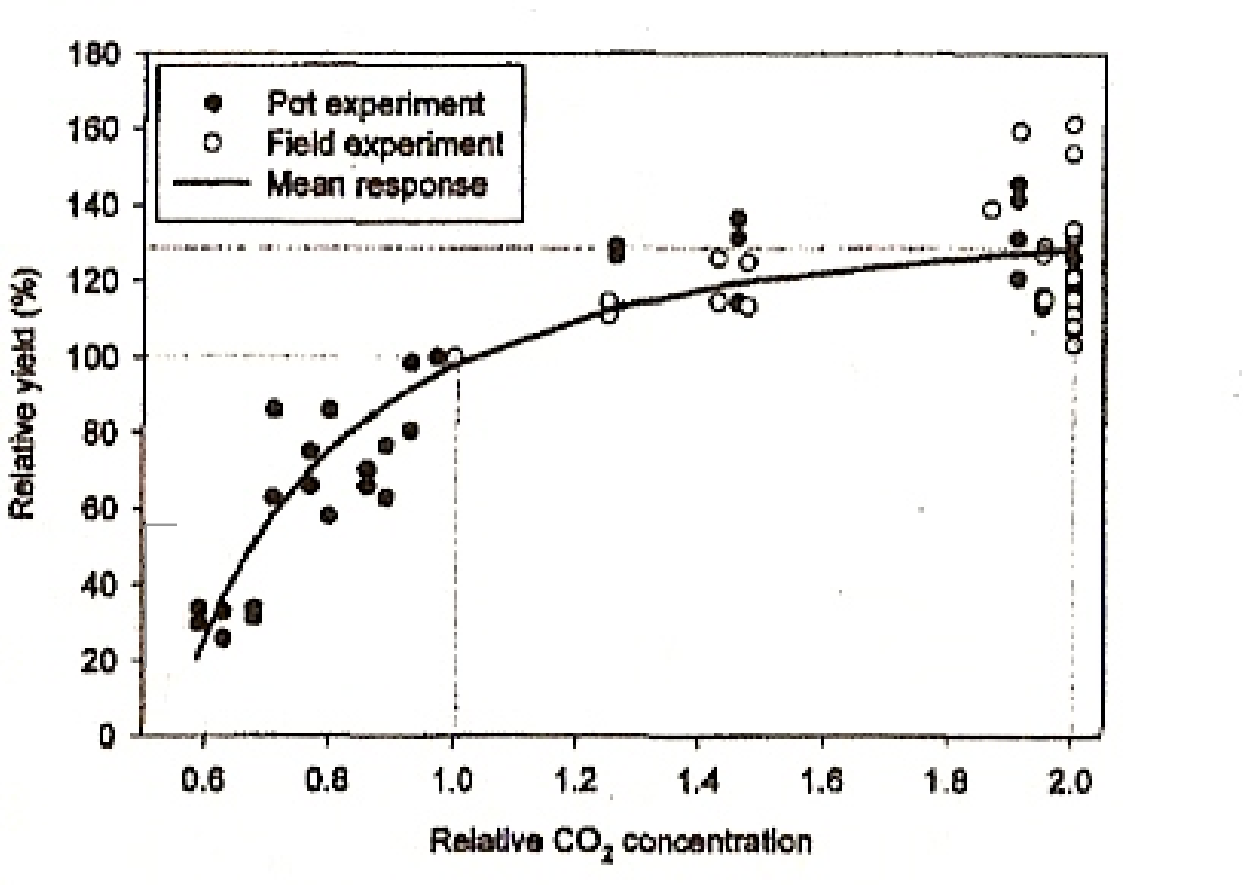
Impact of greenhouse gases

- Relation between higher CO_2-level, impact on plant production:
  - Increased leaf area, leaf thickness, higher number of leaves, higher total leaf area per plant, stems + branches increased diameter
  - Enhanced photosynthesis, increased water use efficiency, reduced damage from troposphere ozone (O_3)
  - Lower decomposition rates could increase number of pathogens & pests that overwinter → higher inoculum levels

Impact on agriculture in the Netherlands

Impact of greenhouse gases

- Relation between higher CO_2-level and production :



Source: Olesen et al. 2002

Impact on agriculture in the Netherlands

Impact of greenhouse gases

Impact on Plant Production:

- Higher CO_2 concentrations
  - CO_2 +100% → C_3-crop yield +33%
    C_4-crop yield +10%
  - Reduction of stomatal aperture and stomal density
  - Reduction of respiration in darkness
  - C/N-ratio will be changed

Impact on agriculture in the Netherlands

Impact of greenhouse gases

Relative CO_2 effect (%)

	Winter	barley	sugar	beet	Winter	wheat
Year	**2000**	**2003**	**2001**	**2004**	**2002**	**2005**
Biomass	8.1	17.6	8.1	6.6	14.5	15.2
Yield	7.5	16.4	7.8	7.1	15.6	15.8
Canopy photosynthesis	18.1	26.1	41.5	32.5	36.9	25.5
Canopy evapotranspiration	-6.2	-12.2	-18.6	-13.5	-3.6	-20.2

Source:: Weichel et al., 2008

Impact on agriculture in the Netherlands

Impact of greenhouse gases

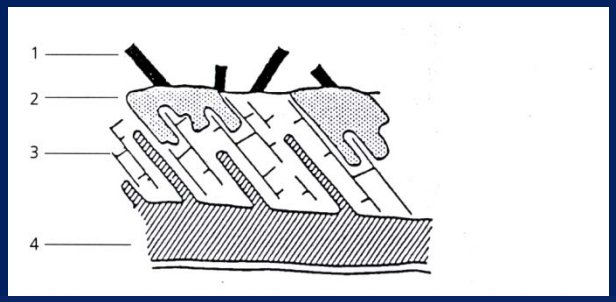
Organism	CO_2 concentration	Effect:
Alternaria brassicae	>0.117%	Inhibits sporulation
Botrytis cinerea	>4-8%	Spore germination inhibited Mycelial growth inhibited
Fusarium oxysporum	4%	Stimulation of growth
Phytophthora capsici	5-15%	Reduction of oospore production
Rhizoctonia solani	>10%	Effect on mycelial growth

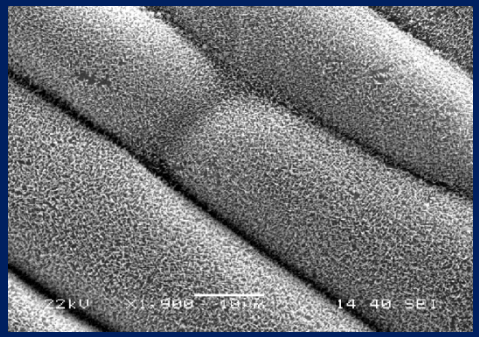
Source: Manning & Tiedemann, 1995

Impact on agriculture in the Netherlands

Impact of greenhouse gases

- Damage of troposphere O_3:
  - Altering:
    - Chemical composition of surfaces
    - Structure of epicuticular wax
  - Change of leaf wettabilty
  - Reduction of uptake of some Plant Protection Products
  - Increase of necrotrophic and foot-rot fungi





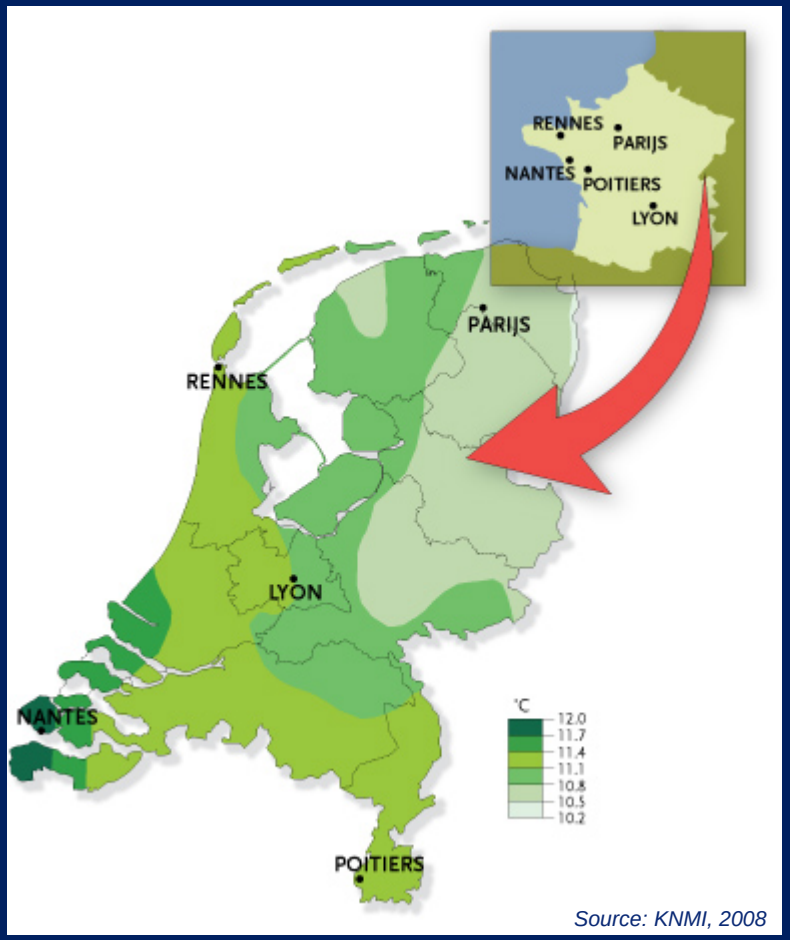
Impact on agriculture in the Netherlands

Management strategies

- Change of insect pests, diseases and weeds
- Effectiveness of Plant Protection Products
- Change in host resistance

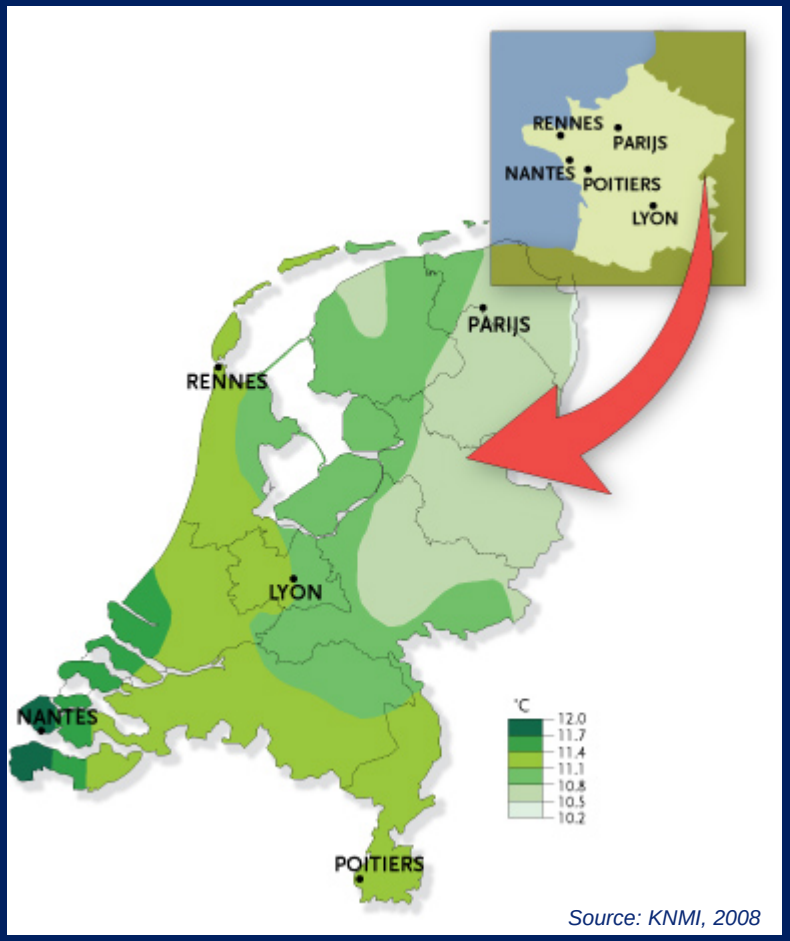
Impact on agriculture in the Netherlands

Geographical distribution of pests



Mean temparature 2006 + 2007 and mean temperature (climatical) of some cities in France

Impact on agriculture in the Netherlands



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Impact on agriculture in the Netherlands

Effectiveness of management strategies

Insect pests:

- Conditions are more favourable for pests
- Complete a greater number of reproductive cycles
  - 2°C increase → 1 to 5 additional life cycles/season
- Change in geographical distribution
- Changes in crop-pest synchrony
- Changes in predator-insect synchrony
- Affected by amount and quality of host biomass
- Disturbance of synchrony between temperature and photoperiod
- Overwintering in “new” areas
- Probably, a higher input of Insecticides

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Overwintering in “new” areas:

- The minimum temperatures are important and not the mean temperatures
- Example: March 2005: Monthly average 6.5°C (Normal: 5.8°C)

Impact on agriculture in the Netherlands

Effectiveness of management strategies

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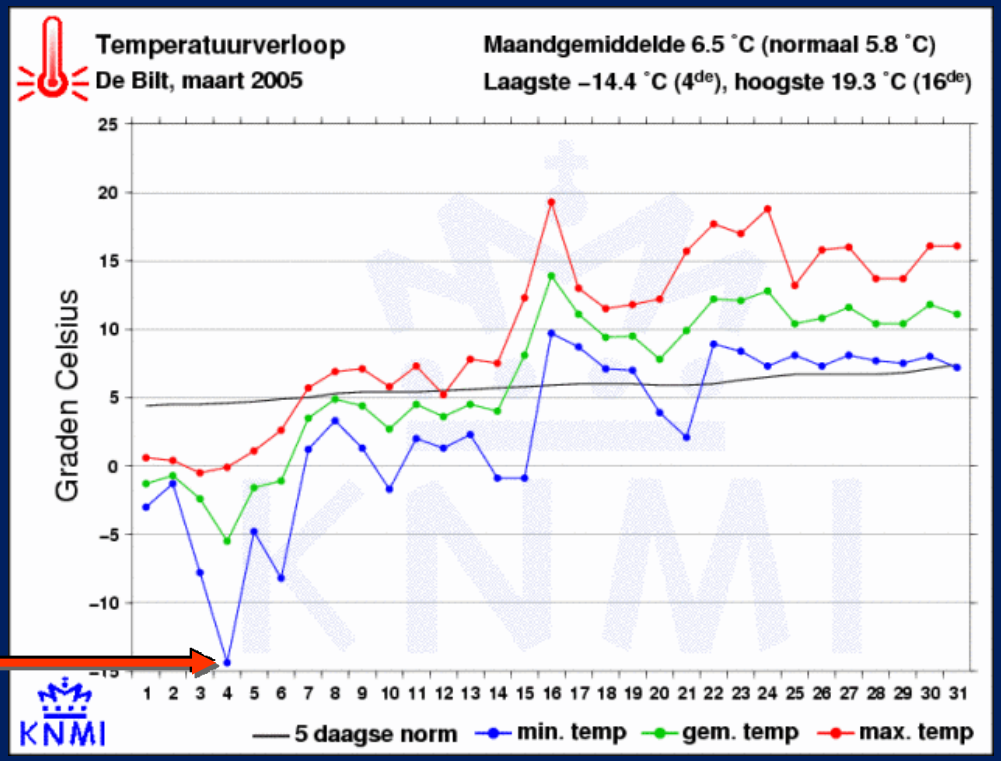

Minimum temperature –15°C, at soil level –20°C

Impact on agriculture in the Netherlands

Effectiveness of management strategies

- Aphids, virus vector:
  - First day of flight, 14 days earlier for every degree rise in temperature
  - Planting dates are not advancing as fast as first flight dates
  - Aphids arrive when crops are earlier and in a more susceptible growth stage
  - Continuously parthenogenic aphids:

(25-30% more generations 2°C increase)

Myzus persicae

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Effectiveness of management strategies

Western corn rootworm
Diabrotica virgifera

Maize stem borer
Ostrinia furnacalis

Robinia gall midge
Obolodiplosis robiniae

Oak Processionary
Thaumetopoea processionea

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Effectiveness of management strategies

Insect pests: Cabbage Whitefly, *Aleyrodes proletella*

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Insects:

Fire Bug,
Pyrrhocoris apterus

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Effectiveness of management strategies

Swede midge
Contarinia nasturtii

With higher temperatures 4 to 5 generations, but per generation a higher percentage went into diapause.

Western Flower Trips
Frankliniella occidentalis

With higher temperatures, increased risk of glasshouse pests that can survive outside

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Effectiveness of management strategies

Westland/Hoek van Holland

Green bridges

Areas with glass-houses and urban regions where insects can survive.

Impact on agriculture in the Netherlands

Effectiveness of management strategies

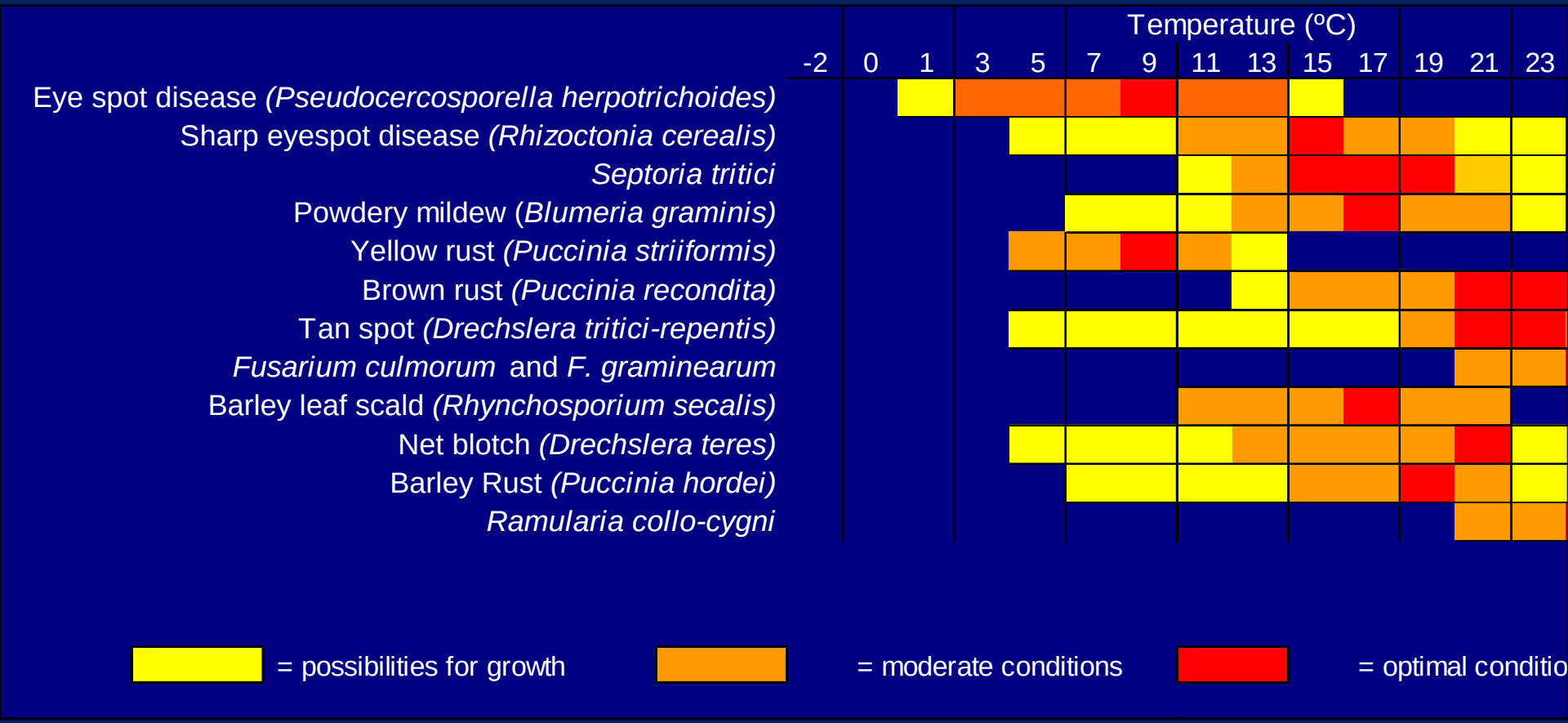
Fungal diseases:

- Conditions are more favourable
  - Shift of disease species
  - Denser plant growth
  - Higher temperature has impact on the effectiveness of some host resistance genes
  - Systemic fungicides have a shorter efficacy

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Fungal diseases:



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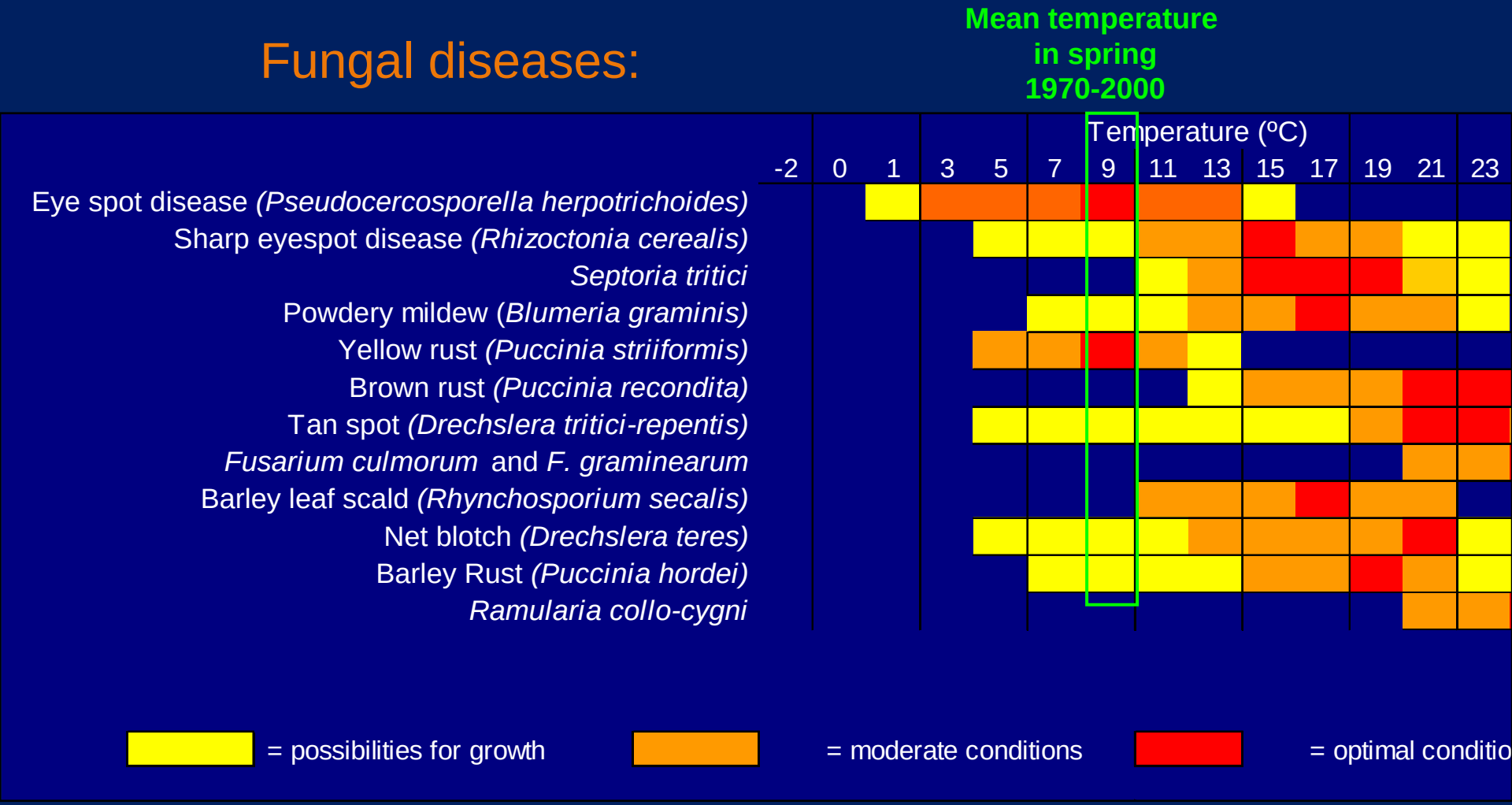

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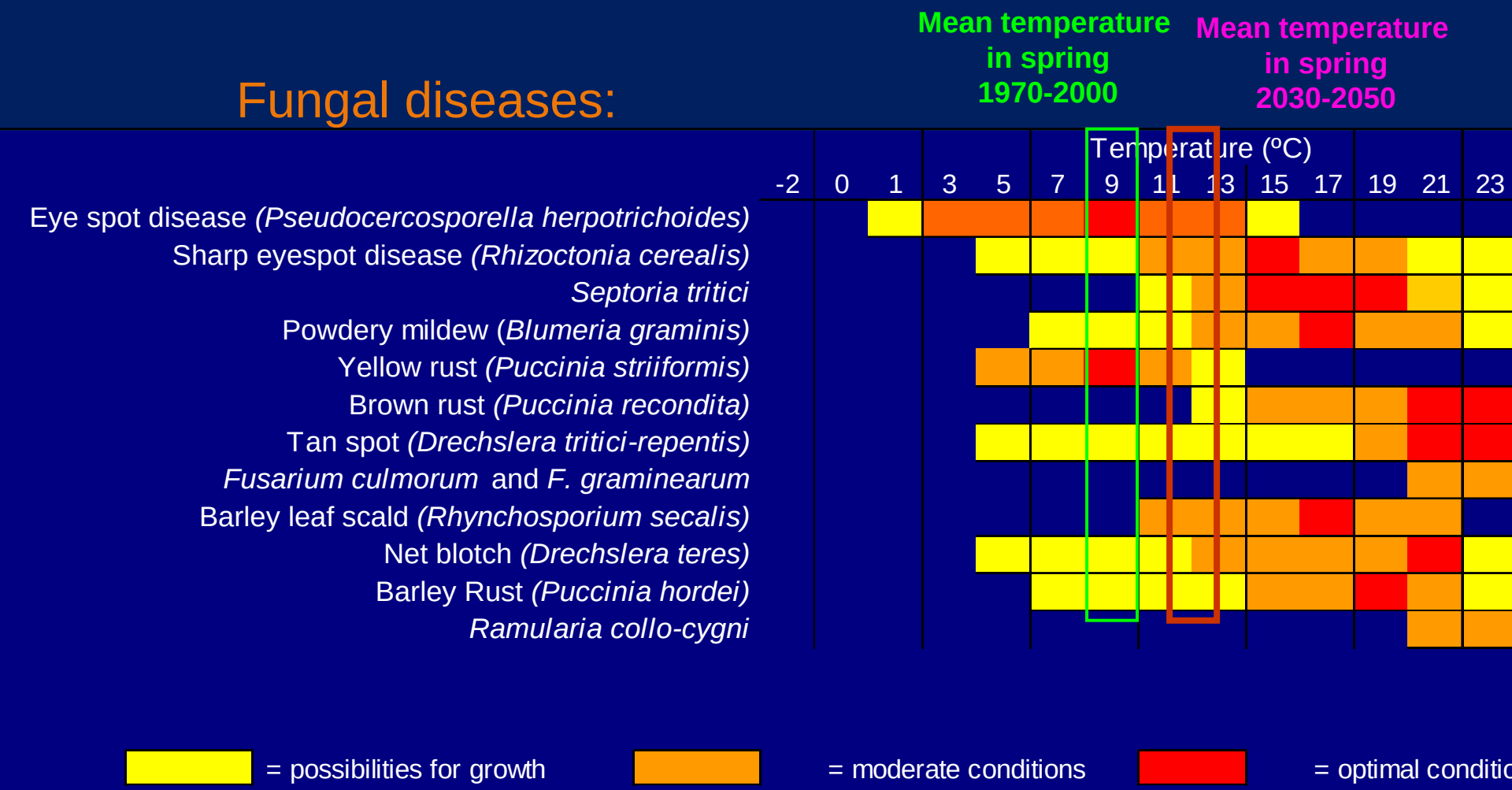

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Effectiveness of management strategies

Fungal diseases:

- Decrease of “chilly”-preferring diseases :
  - *Phoma exiqua foveata*
  - *Typhula incarnata*

- Increase of “higher temperature” favourable diseases:
  - Barley yellow dwarf virus (BYDV)
  - Brown rust diseases
  - Tan spot
  - Powdery Mildew
  - *Cercospora beticola*
  - *Ramularia beticola*

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Diseases:

Introduction of new diseases:

Maize:

- *Helminthosporium turcicum*
- *Helminthosporium carbonum*

Helminthosporium turcicum

Source:PPO-agv

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Weeds:

- Weed control more difficult:
  - Faster breakdown of soil acting herbicides, e.g. of sulfonylurea herbicides

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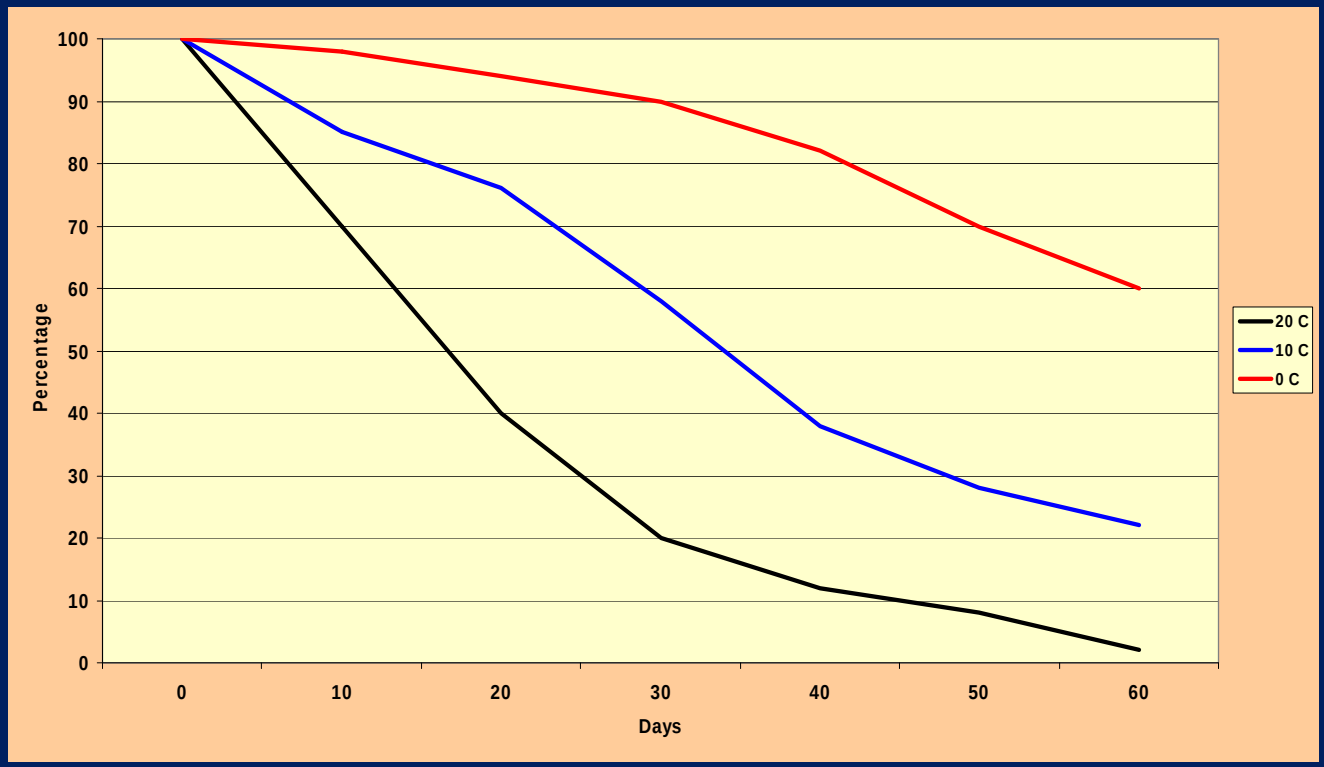

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Weeds:

- Weed control more difficult
  - Faster breakdown of soil acting herbicides
  - Reduced soil moisture in spring

- Conditions are more favourable
  - Higher CO_2-concentrations stimulate C_3 and C_4

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Weeds:

Velvetleaf
Abutilon theophrasti

Common ragweed
Amaranthus artemisiifolia

Green Brislegrass
Setaria viridis

Millet-grass

Barnyardgrass
Echinochloa crus-galli

Cut-Leafed Cranesbill
Geranium dissectum

Black nightshade
Solanum nigrum

Fat-hen ,
Chenopodium album

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Disease/pest/weed	increase	decrease	applications PPP
Nematodes	+		?
Rhizoctonia solani			0
P. infestans	+		+2
Alternaria spp.	++		+2
Erwinia (*Dickeya*) spp.	+		?
Verticillium spp.	+		?
Aphids (Viral diseases)	++		+3
Monocot weeds	+	+	0
Dicot weeds	+	+	0
Total			**+7**

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Short-term adjustments:

- Adaptation of IPM
  - Changed insect/predator relations
  - Higer disease presure
  - Higher weed pressure with other weed species(?)
- Higher frequency of the use of pesticides

Impact on agriculture in the Netherlands

Effectiveness of management strategies

Long-term adjustments:

- Major structural change
  - Breeding of heat and drought resistant varieties

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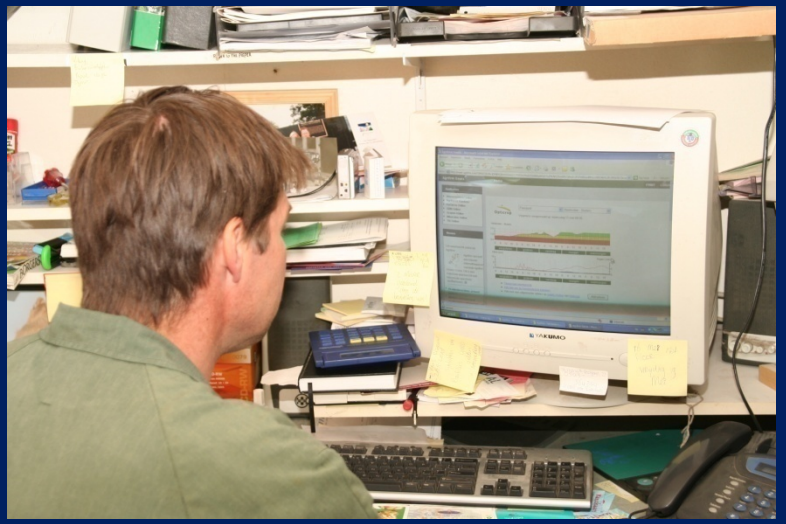
Effectiveness of management strategies

Control of Pest, Diseases and weeds:

- Possible to adjust the optimal application moment and choice of the PPP by help of Decision Support Systems



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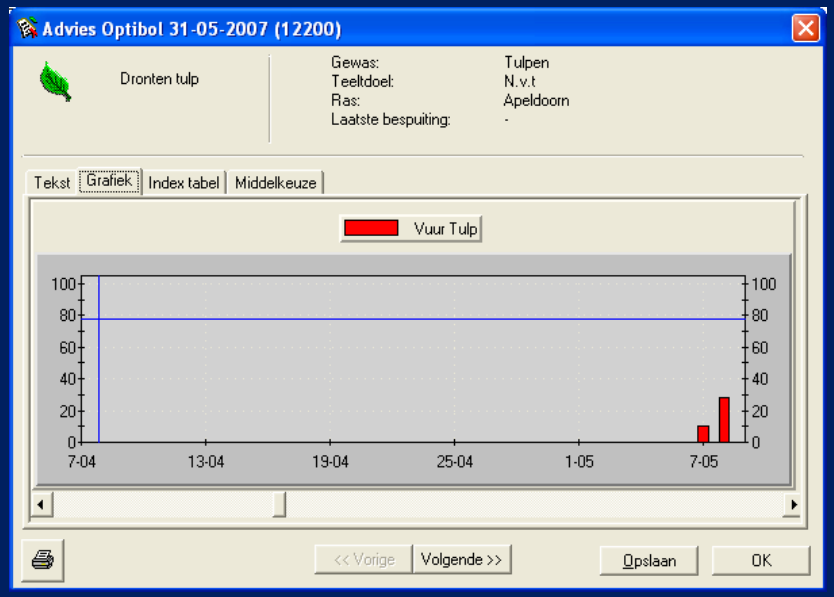

Impact on agriculture in the Netherlands

Effectiveness of management strategies

- Decision Support Systems:
  - available in a large number of crops against:
    - Insect pests
    - Fungal diseases
    - Weeds
  - DSS have approved their sustainability and possibilities to provide secure advices

Impact on agriculture in the Netherlands

Conclusions:

- Influence on agronomics due to greenhouse gases
- Changed pest/host relations
- Higher disease and pest pressure (by new organisms)
- Higher and earlier weed pressure (other weed species)
- Higher frequency of the use of pesticides
- Possible to adjust the optimal application moment and choice of PPP by help of Decision Support Systems

Conclusion:

- **Yes,**
  Climate Change have an impact on agriculture and crop protection in the Netherlands in 2050!

Thank you for your attention!