Effects of climate change on pest development and spread and implications for IPM

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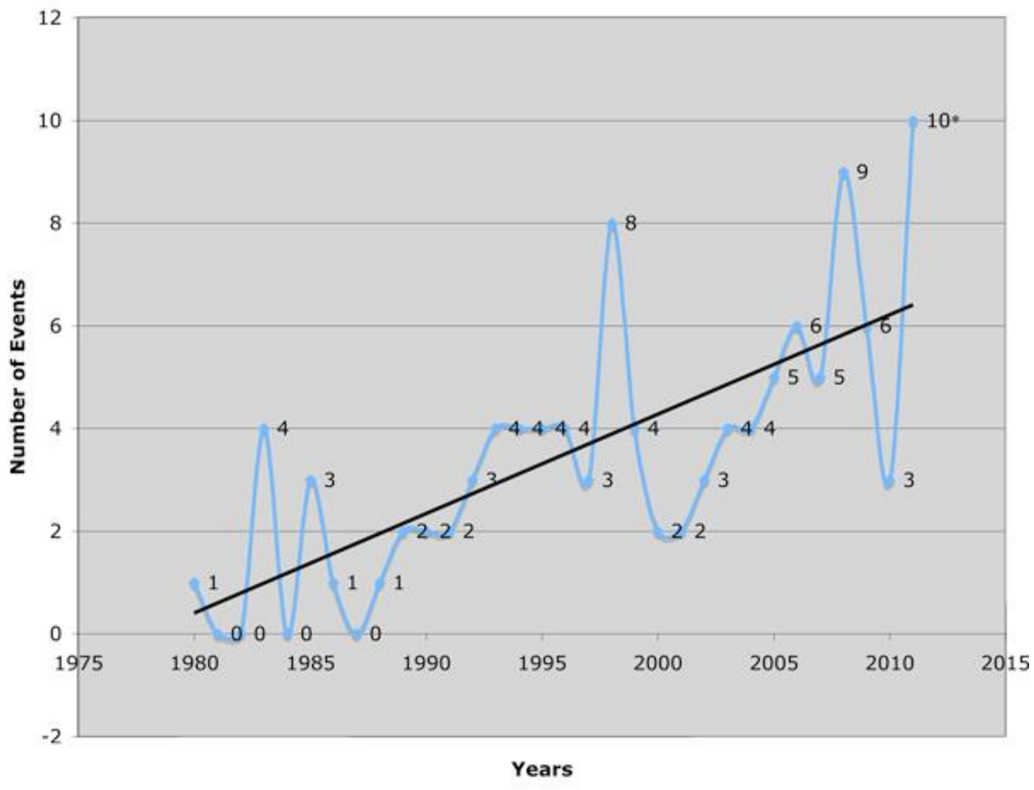
Is climate changing?

- **Changes in the frequency of extreme events**

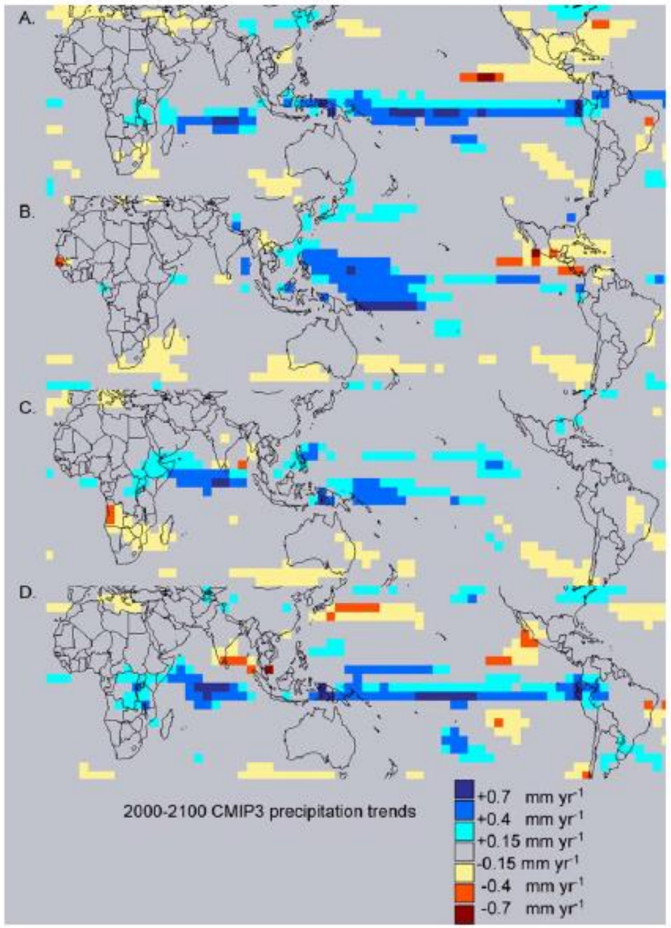


Source: National Climatic Data Center (NCDC), USA

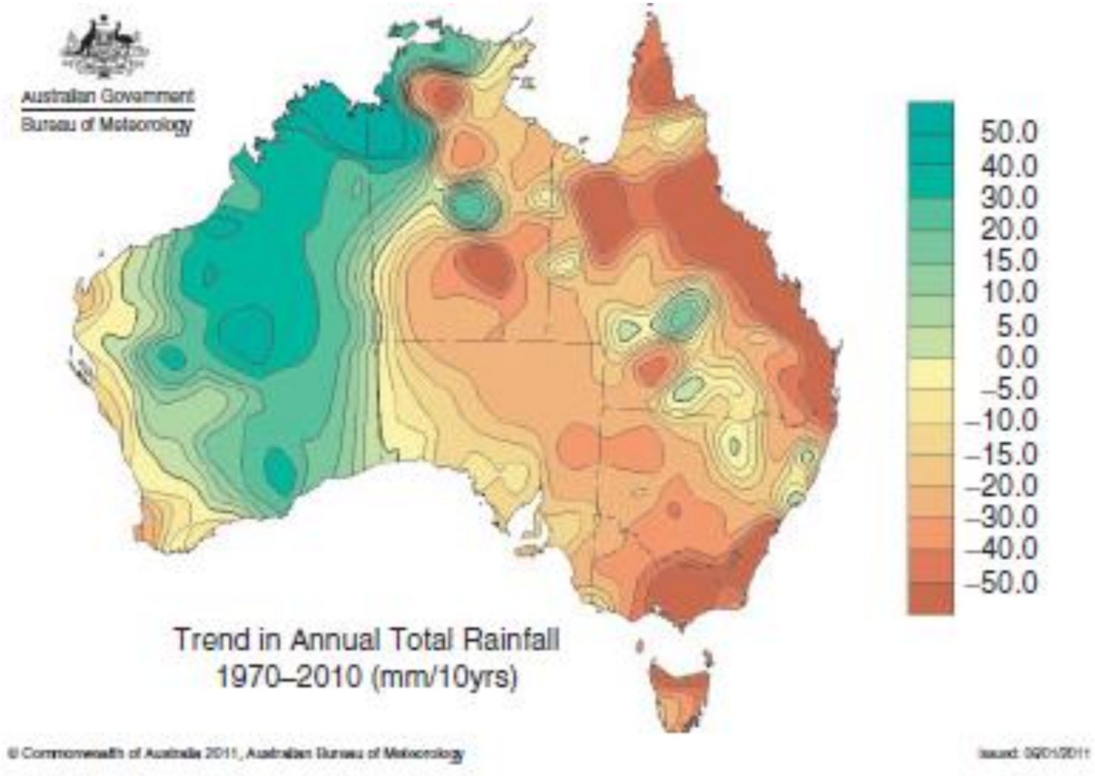
Is climate changing?

Altered levels of precipitation

Fig. 4 Predicted precipitation changes for the 21st century, based on a large set of climate change scenarios (See Table 2). The outputs from these simulations were averaged for each quarter (March-April-May: A, June-July-August: B, September-October-November: C, December-January-February: D). Trends for the time period 2000–2100 were then calculated and plotted. The model simulation shows substantial increases in rainfall over the oceans



Funk and Brown, 2009



Sutherst et al 2011

What altered levels of precipitation mean?

- >Rainfall = >moisture = > higher crop diseases

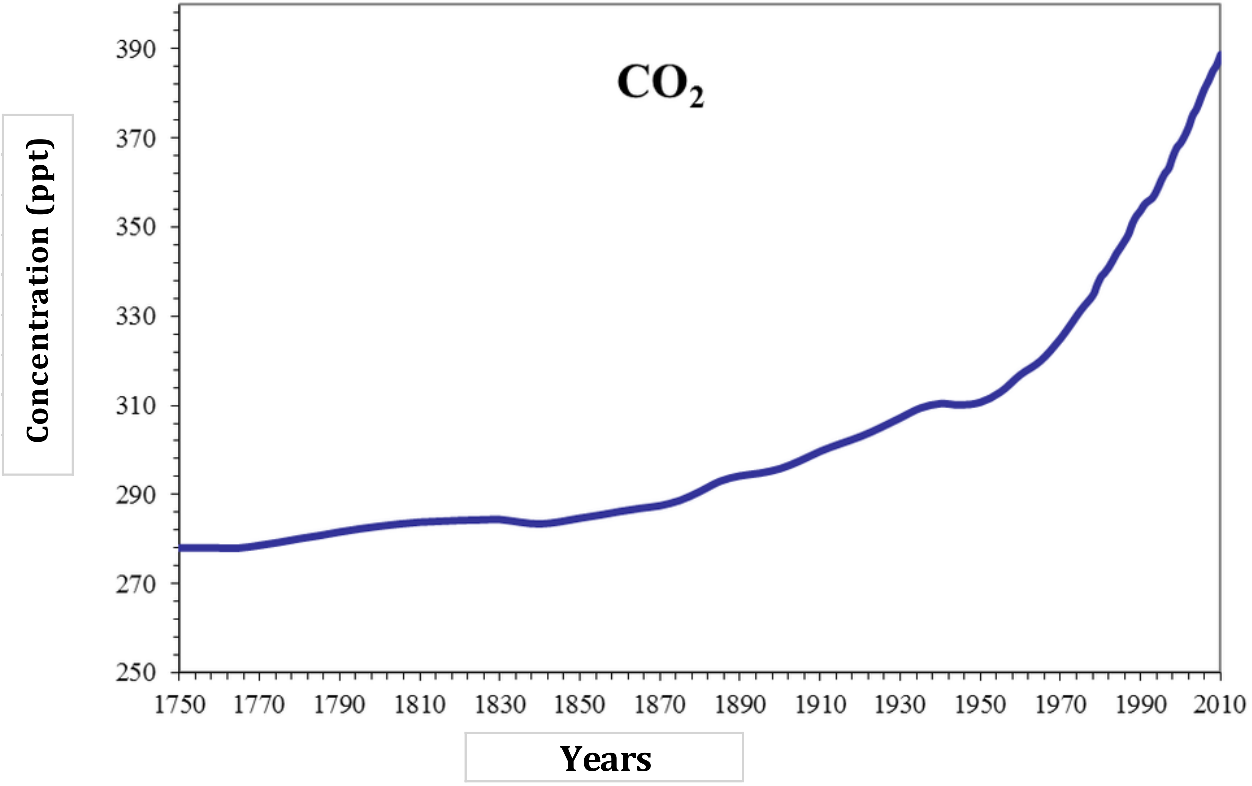
Powdery mildew of grapevine caused by *Erysiphe necator*

Bacterial speck of tomato caused by *P. syringae*

- <Rainfall = drought

Is climate changing?

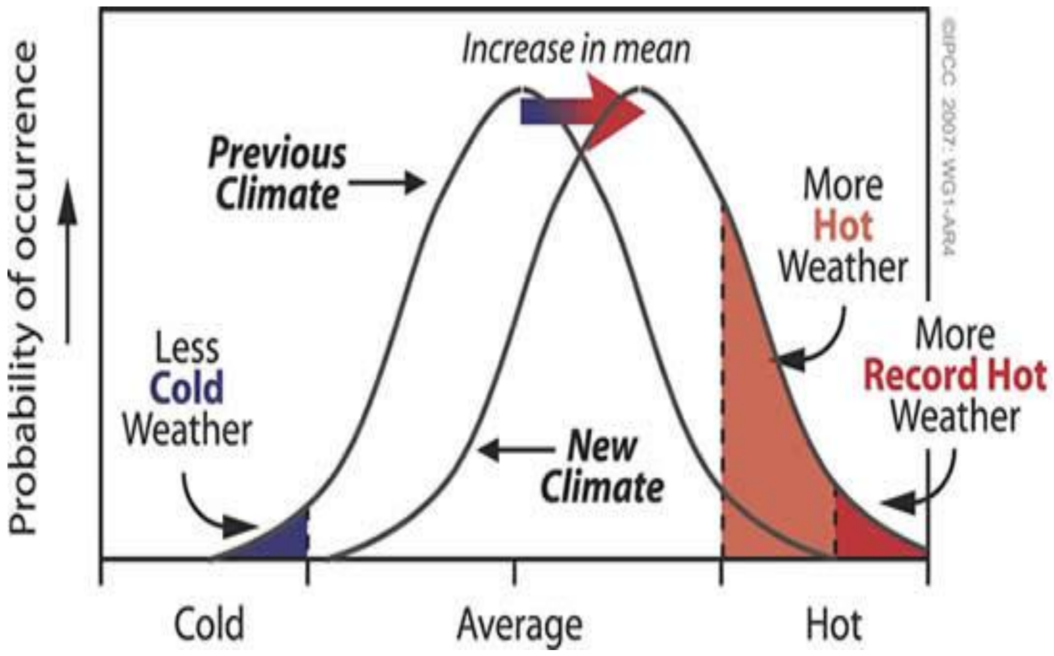
Higher CO2 levels



Source: National Climatic Data Center (NCDC), USA

What higher CO_2 levels mean?

- Increased rate of photosynthesis
- Accelerated life cycle of pathogenic fungi (Chakraborty and Dutta 2003)
- **Increases in global temperature**



(Solomon et al. 2007)

Increases in mean temperature: Impact on pests

- The rates of growth, development, and mortality of pests are altered

- Elevated temperatures may result in:
  - Population increases due to shorter life cycles and faster generation times
  - Less cold stress and longer growing seasons for warm climate pests and more heat stress for temperate species
  - **Pest range shifts:**
    - From lower latitudes pole-wards
    - From lower to higher altitudes
  - **Changes in pathogen prevalence**
  - **Pest evolution toward aggressive strains/biotypes**

Increases in mean temperature: Impact on pests

Global Change Biology

Global Change Biology (2013) 19, 1985–2000, doi: 10.1111/gcb.12205

REVIEW

Migrate or evolve: options for plant pathogens under climate change

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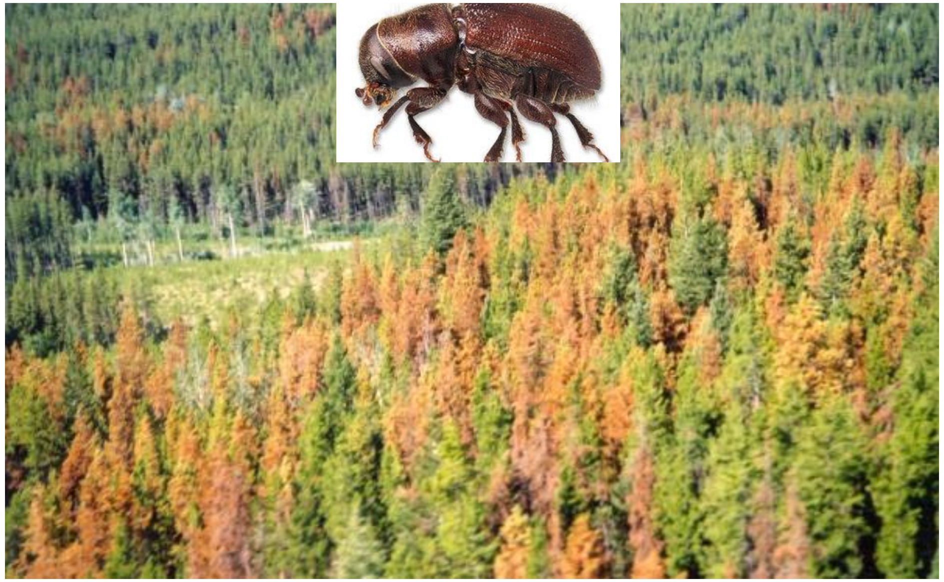
Increases in mean temperature: Impact on pests

Pest range shifts

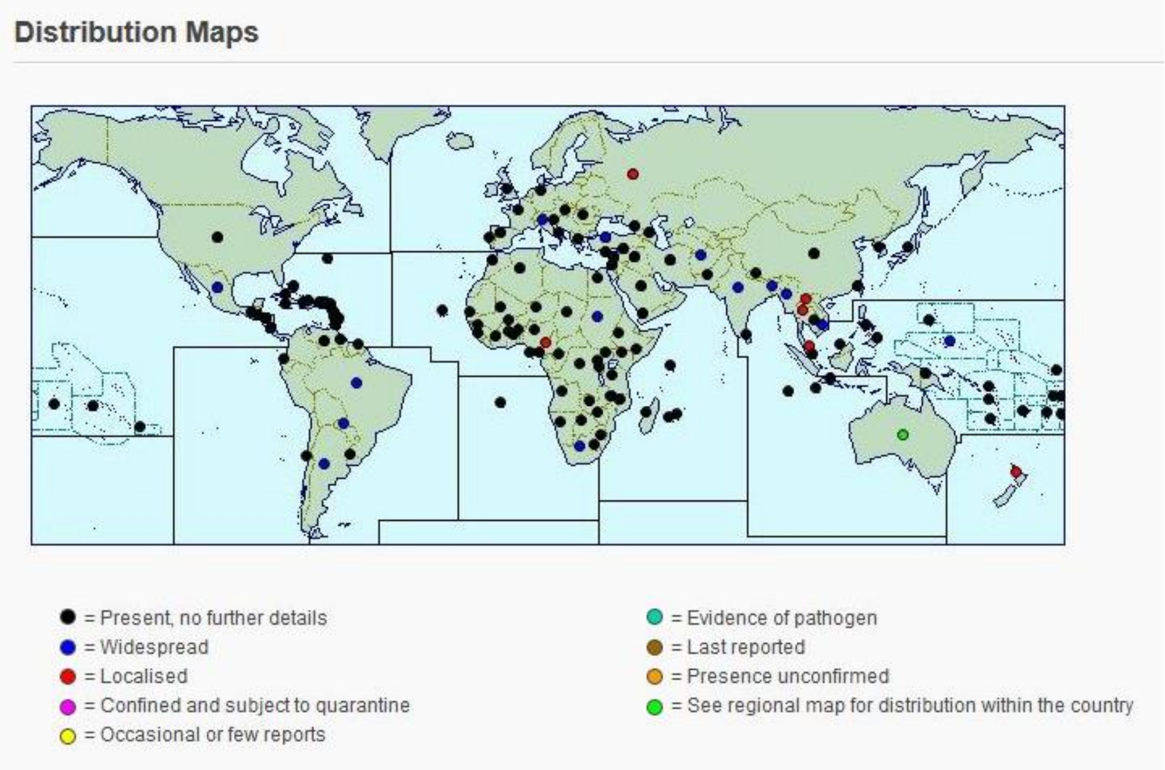
- The mountain pine beetle, a major forest pest in the USA and Canada
  - Approx. 300 km range extension Northwards when temperature rose by only 2 °C (Logan and Powell 2001).
  - 11 million ha affected in a recent 13 year period (Sutherst et al 2011)



Increases in mean temperature: Impact on pests

Pest range shifts

- The green stinkbug in England and Japan
  - Range shift by more than 300 km northward with a temperature increase of only 2 °C (Trumble and Butler 2009)



Increases in mean temperature: Impact on pests

Pest range shifts

- The distribution range of the European corn borer will be extended to maize areas previously free of this species

- *Phytophthora cinnamomi* and associated diseases will be extended due to warmer winters and fewer frosts (Bergot et al 2004; Marcais et al 2004)

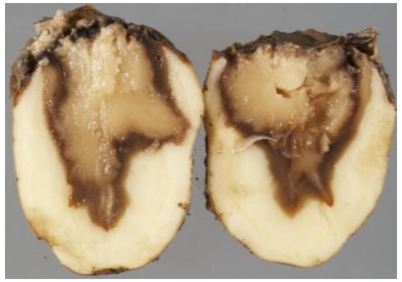
Increases in mean temperature: Impact on pests

Substitution of a previously existing dominant pest species by a new one

- *Fusarium* spp. and *Microdochium* spp. in Europe by *F. pseudograminearum* with higher temperature optima and toxigenicity (Isebaert et al. 2009)

Crown rot of wheat caused by *F. pseudograminearum*

- *Pectobacterium* spp. by *Dickeya* spp. in Northen Europe (Czajkowski et al. 2011)



Dickeya spp.

Increases in mean temperature: Impact on pests

Enhanced severity: disease complexes

- The defoliation of the eastern white pine (*Pinus strobus*) across the northeastern United States

Global Change Biology

Global Change Biology (2016), doi: 10.1111/gcb.13359

Emergence of white pine needle damage in the northeastern United States is associated with changes in pathogen pressure in response to climate change

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White pine needle disease

Increases in mean temperature: Impact on pests

Changes in pathogen prevalence

- In China, an increase in average annual temperature from 1950 to 1995 has led to :
  - An increase in the prevalence of powdery mildew and wheat scab (both warm climate diseases)
  - A decrease in wheat stripe rust, *Puccinia striiformis* (a cool climate disease) (Yang et al 1998)

- Northwards expansion of native and invasive weed species is foreseen due to raising temperature (Hatfield et al. 2011).

Increases in mean temperature: Impact on pests

Some regions of the world is supposed to be an ‘invasion hotspot’ under climate change

EPPO Lists of Invasive Alien Plants

EPPO, in the framework of the International Plant Protection Convention (IPPC) and the Convention on Biological Diversity (CBD), is developing a cooperative Europe-wide strategy to protect the EPPO region against invasive alien plants. In 2002 the EPPO Panel on Invasive Alien Species was created and was given the task to identify invasive alien plant species which may present a risk to the EPPO region, and to propose management options.

The number of plants that can be considered as potential pest species is very large and the Panel has elaborated a **prioritization process** for all known, or potential invasive alien plants in the EPPO region. During this process the Panel is documenting invasive alien plant species on data sheets and when necessary, conducting Pest Risk Analyses (PRAs) following the EPPO Decision-support scheme, **'Pest Risk Analysis for quarantine pests'**.

As a result of these studies, the following lists of invasive alien plants have been established (click on the links to view their status and contents):

- **EPPO A1/A2 Lists of pests recommended for regulation as quarantine pests**
- **EPPO List of invasive alien plants**
- **EPPO Observation List of invasive alien plants**
- **EPPO Alert List**

Information about potentially invasive plants which were studied but not retained in the EPPO Lists can still be accessed:

- Other documented plant species

Pictures: Frank Billeton (FR) and Sarah Brunel (EPPO)

Increases in mean temperature: Impact on crops

- Altered levels of suitable cropping areas with a poleward expansion (Olesen and Bindi, 2002; Rosenzweig et al 1994)
  - Winter wheat, maize, and vegetables are likely to increase
  - Spring wheat, barley, and potato cultivations are likely to decrease

- Altered crop growth and anthesis
  - Early development of wheat in the season means more favorable for Fusarium ear blight infection and mycotoxin productions (Madgwick et al. 2011)

Increases in mean temperature: Impact on crops

- Impact on the expression of plant resistance traits
  - An increase in 5°C led to a drastic drop of the expression of quantitative resistance against Phoma canker in oilseed rape (Huang et al. 2009)

- Elevated temperatures can suppress defense responses in plants resulting in increased severity of disease as observed for bacterial spot of bell pepper (Romero et al 2002)

Increases in mean temperature: Other impacts

Altered level of crop-weed competition

- Weeds may respond more favorably to climate change than crops although C3 or C4 crops respond differently to increased level of CO_2 (Hatfield et al. 2011; Ziska 2011)

Altered level of pesticide performance

- The efficacy of glyphosate is reduced at high temperatures on resistant weed populations, making these weed populations difficult to manage
- The fungicide sensitivity of Pythium spp., that causes soybean and corn damping off, reduces at elevated temperature (Matthiesen et al., 2016)

But climate change-driven global warming have also beneficial effects

- Improved crop yield potential for certain crops (wheat, paddy rice) across certain regions

- Reduced risks of pathogen attacks across certain areas (Chakraborty 2005)
  - Global warming is likely to result in fewer frosts, which can be a limiting factor for plant pest and pathogen development (<number of frosts = < injury points on plants = < ports of entry)

Agriculture may also impact climate change!

- Crop protection *per se* has an important role to play in mitigating climate change
  - Reduction of GHG emissions

So what implications for IPM due to climate change?

- The sensitivity of each cropping system to pests under climate change will depend on:
  - The crop and pest species and their geographical location
  - Influence of local or international markets involved

- IPM has a strong potential to reduce impact of pests under CC both off-farm and on-farm (Sutherst et al 1996; 2000)
  - On-farm impact: highly localized and field-specific
  - Off-farm impact: regional-scale changes

- **Study on the real impact of climate change is a challenging task**
  - Difficulties to isolate the effects of climate change from those of other concurrent changes (global and land use changes etc.) and define the interactions (Sutherst et al 2011)

So what implications for IPM due to climate change?

- IPM *per se* is a dynamic process adaptable to specific regional and site-specific conditions
  - Adaptation to change is imperative

- Adaptive management (central to all pest management decisions)
  - A dynamic decision making approach to respond to changing conditions that requires an ongoing process of pest monitoring and evaluation
  - Resilient and sensitive PMS to regional climate change and its great inherent uncertainties

- The adaptive capacity will depend on a number of factors
  - Physical, social, and financial resources,
  - Resource-poor societies are more vulnerable to climate change if food production systems are not resilient to the potential impacts

Priorities and action plans to adapt/improve current crop protection practices (IPM)

- Overall 7 priorities and action plans proposed by ENDURE

1) Human resources

- Reverse the decline in skilled crop protection specialists
  - Problems related to pests resistance development (emphasis on non-chemical tools)
  - Identifying new and more aggressive pest strains/biotypes requires highly skilled staff and technical expertise
  - Education and training of farmers and advisors
  - Participatory approach and networking across borders

Priorities and action plans to adapt/improve current plant protection practices (IPM)

- Overall 7 priorities and action plans proposed by ENDURE

2) Resilient cropping systems

- Cropping systems resilient to extreme, variable, and unpredictable situations
- Diversification of cropping systems

Priorities and action plans to adapt/improve current plant protection practices (IPM)

- Overall 7 priorities and action plans proposed by ENDURE

3) Crop-weed competition under climate change

  - Use of crop species possessing competitive traits (faster germination, quick growth, high biomass, large leaf area)
  - High seed rates and narrow row spacing
  - Weedy rice response under elevated CO2

Priorities and action plans to adapt/improve current plant protection practices (IPM)

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4) Anticipation and international and/or global coordination

  - Effective tracking of pest populations in a timely fashion with alert systems
  - Shared platforms: Eurowheat & Euroblight
  - The Borlaug Global Rust Initiative

Priorities and action plans to improve current plant protection practices

Overall 7 priorities and action plans proposed by ENDURE

5) Breeding for resistance and/or better deployment

- Varieties adapted to regional and site-specific climates and those containing temperature-stable resistance genes
- Focus on breeding for minor crops (reduced reliance on conventional pesticides, enhanced resilience of major crops)

Priorities and action plans to improve current plant protection practices

- Overall 7 priorities and action plans proposed by ENDURE

6) Biological control

- Reduce reliance on conventional pesticides, especially in arable crops
- Contain the risks related to pest resistance evolution to conventional pesticides
- Re-store natural pest regulation systems

Priorities and action plans to improve current plant protection practices

- Overall 7 priorities and action plans proposed by ENDURE

7) Pest risk analysis

- As early warning tools to assess potential pest introduction and establishment
- A key approach to ensure ‘plant health’ based on enhanced international information exchanges

For more information

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REVIEW ARTICLE

Robust cropping systems to tackle pests under climate change. A review

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diversifying crop protection

THANK YOU
FOR YOUR ATTENTION
ANY QUESTIONS...?