An assessment of the risk of aerial transport of rust pathogens to the Western Hemisphere and within North America

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Question

How frequently are there opportunities for rust pathogens to be transported:

1. From locations in the Eastern Hemisphere to the Western Hemisphere

2. From locations in subtropical regions to the continental interior of North America
Aerobiota Transport Process Model

Horizontal Transport

Takeoff and Ascent

Descent and Landing

Earth’s atmosphere

Pre-conditioning

Impact

Earth’s surface

SOURCE AREA

DESTINATION AREA

“opportunities” – consideration of processes that occur in the atmosphere
Integrated Aerobiology Modeling System (IAMS)

Synoptic Scale Airflows Govern Transport Direction and Speed
Turbulent Diffusion and Wind Shear Govern Dilution

Turbulent Transport and Dilution in the Atmosphere

Survival of Spores while Airborne

Escape of Spores from Canopy
Vertical Distribution of Spores in Canopy
Canopy Density & Structure
Wind & Turbulence
Time of Spore Release
Plant Growth
Stage of Disease
Weather

Spore Production

Deposition of Spores into a Crop
Dry Deposition Due to Wind and Turbulence
Wet Deposition Due to Washout by Precipitation
Temperature & Leaf Wetness
Crop Growth Stage

Colonization of Crop

Ultraviolet Radiation
Temperature and Relative Humidity

Potential Destination Regions Used in Analysis
- Grid spatial resolution was 0.083 degrees (~ 14 km),
- Vertical resolution was defined by the standard pressure levels (1000, 950, 900, 850, 800, 700, 600, 500 hPa)
- One hr time step.
- National Center for Environmental Prediction–Department of Energy Reanalysis 2 data set for the 1998-2007 period
- Each simulation was initiated for 1 January 1998 with the daily spore production held constant for the duration of the 10-yr run.
- Nine grid cells (equivalent to about 125,000 ha at the Equator), distributed throughout a source area, were assumed to have a healthy crop and rust infection severity of 50%.
- Parameters for the spore release and escape, dispersion, mortality and deposition modules were those used in a previous soybean rust study (Isard et al. 2007)
Frequency of Days with Deposition of Viable Rust Spores in Western Hemisphere as Simulated by IAMS for 1998-2007

Averaged for Year
Frequency of Days with Deposition of Viable Rust Spores from Eastern Hemisphere Source Regions in U.S. & Canadian Destination Regions

Simulated by IAMS for 1998-2007

Averaged for entire year
Frequency of Days with Deposition of Viable Rust Spores from African Source Regions in the Caribbean Islands

Averaged for entire year

Simulated by IAMS for 1998-2007
Frequency of Days with Deposition of Viable Rust Spores from African Source Regions in Eastern South America

Trade Winds

January

July

Simulated by IAMS for 1998-2007
Summary of Insights from IAMS Simulations

The frequency of trans-oceanic transport and deposition of viable rust spores in the Western Hemisphere:

- Africa, tropics – low
- Europe, north of Pyrenees/Alps – low
- Eastern Asia/Australia – low
- Africa, poleward of the tropics – high
  - relatively short distance
  - persistent trade winds

Regions in the Western Hemisphere that are influenced by the ITCZ have the highest likelihood of receiving viable rust spores from the Eastern Hemisphere:

- high frequency & high intensity deposition events

Risk of direct aerial transport of viable rust spores to U.S. and Canada - low
Question

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The wind speed and directions are averaged for the air layer between the ground and the height at which air pressure decreases 30 hPa (typically 200 m near mid-day).
Frequency of strong low-level airflows:
South Texas and Delta Regions to designated continental interior regions

Source Regions
1. South Texas
2. Mississippi River Delta Region

Destination Regions
1. South Dakota/North Dakota/southern Manitoba/southeastern Saskatchewan
2. Minnesota/Iowa/Wisconsin/southwestern Ontario
3. Kansas/Nebraska
4. Missouri
5. Illinois/Indiana

Wheat Acres
- 0 - 500
- 500.1 - 1,000
- 1,000.1 - 5,000
- 5,000.1 - 10,000
- 10,000.1 - 20,000
- 20,000.1 - 25,000
- 25,000.1 - 50,000
- 50,000.1 - 100,000
- 100,000.1 - 200,000
- 200,000.1 - 300,000

USDA, National Agricultural Statistics Service
April 2006-2010
Frequency of strong low-level airflows: South Texas and Delta Regions to designated continental interior regions

Source Regions

T. South Texas
D. Mississippi River Delta Region

Destination Regions

1. South Dakota/North Dakota/southern Manitoba/southeastern Saskatchewan
2. Minnesota/Iowa/Wisconsin/southwestern Ontario
3. Kansas/Nebraska
4. Missouri
5. Illinois/Indiana

USDA, National Agricultural Statistics Service

May 2006-2010
Frequency of strong low-level airflows: South Texas and Delta Regions to designated continental interior regions

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USDA, National Agricultural Statistics Service
August 2006-2010
Frequency of strong low-level airflows:
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2. Minnesota/Iowa/Wisconsin/southwestern Ontario

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Wheat Acres

0
0 - 500
500.1 - 1,000
1,001 - 5,000
5,001 - 10,000
10,001 - 20,000
20,001 - 25,000
25,001 - 50,000
50,001 - 100,000
100,001 - 200,000
200,001 - 300,000

September 2006-2010

USDA, National Agricultural Statistics Service
Strong low-level advection of air northward from the subtropics is prevalent in North America east of the Rocky Mountains from early April to mid June providing opportunities for long-distance transport of rust pathogens into the continental interior.

After mid-June, the number of days with strong low-level advection of air from south to north across these regions decreases dramatically.
Risk of long-distance aerial spread of soybean rust less than wheat rust during the periods when they could potentially cause crop losses in major North American production regions.