New foliar and soilborne pathogens recently observed on leafy vegetables for the ready-to-eat sector in Italy

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Outline

- Leafy vegetables -ready to eat salad market

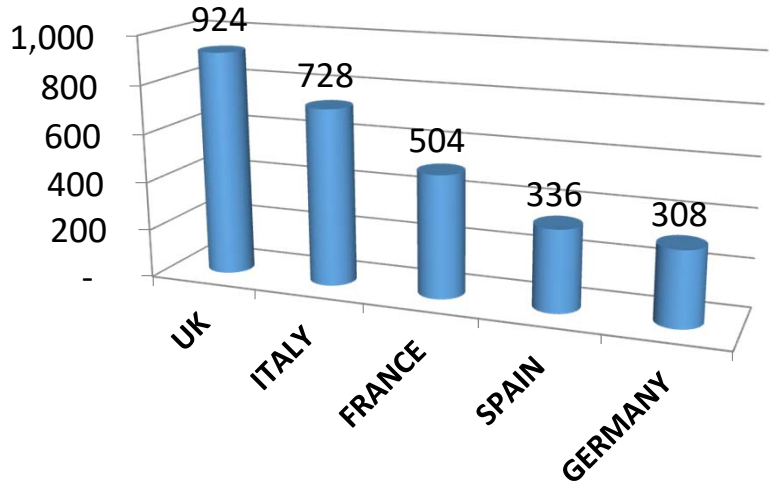
- New foliar and soil-borne pathogens
  - -symptoms and hosts
  - -geographical distribution

- Factors affecting disease spread (e.i. seed transmission/climate change)

- Concluding remarks

Ready to eat processed salad market

Sales of fresh-cut salad products in major European countries and UK (Millions € in 2014)



Italy is first producer in Europe: 97,000 t in 2014 (-0.4% compared to 2013).

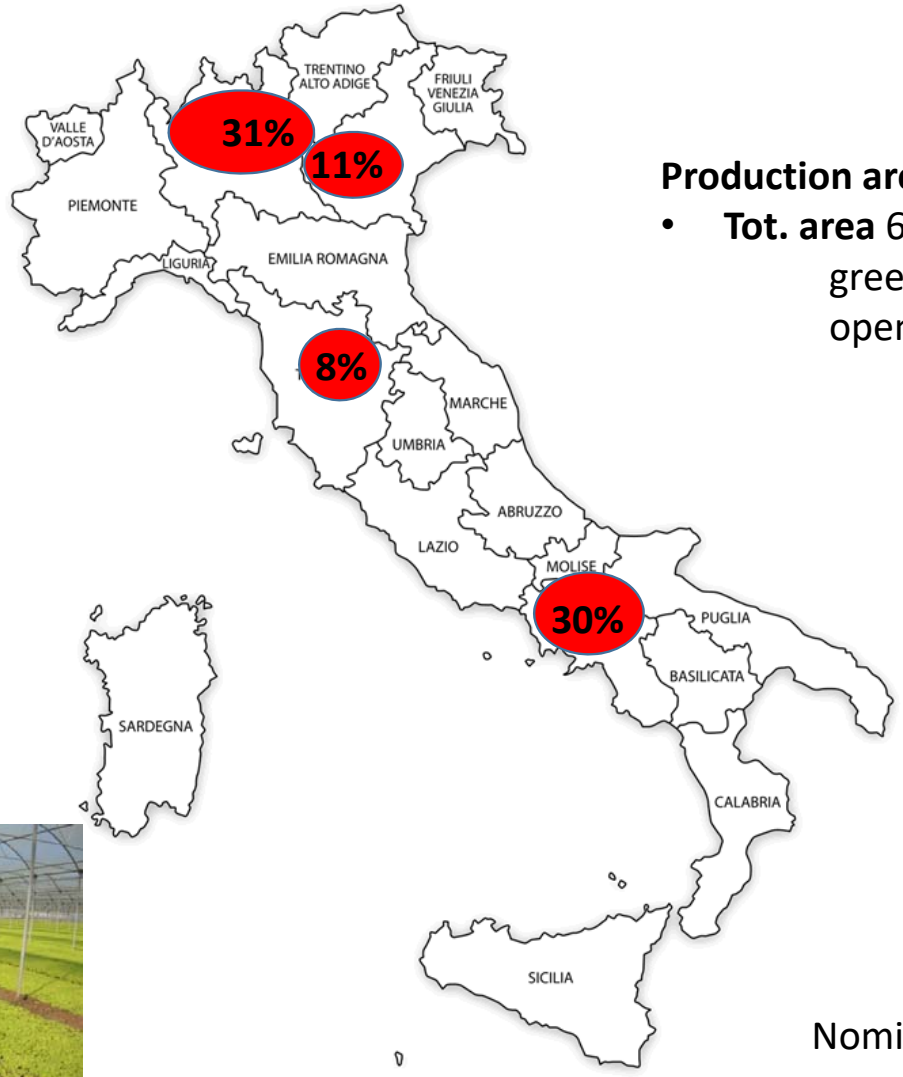
Total value/tot. fruit§veg: 728 millions € (3 % in volume of tot fruit and vegetable in 2013; 2.5% in 2008).

Number of farms: 700

Number of companies: 120 (1,500 workers).

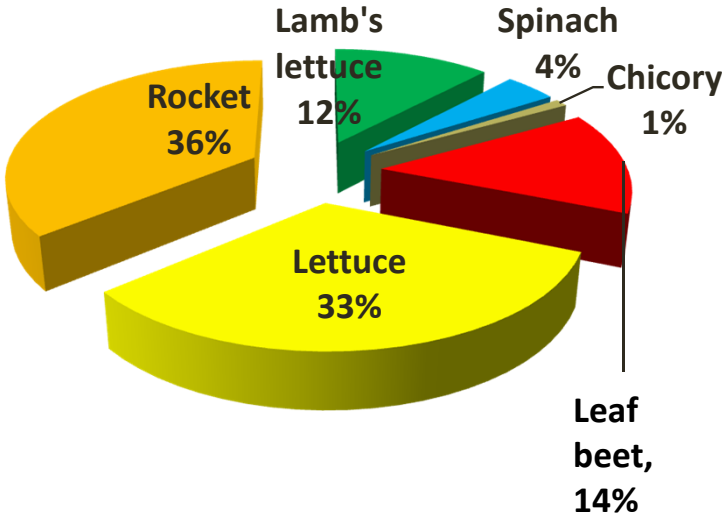
Casati and Baldi, VVA Brussels, 2014.

Ready to eat processed salad sector in Italy



Production areas

- **Tot. area** 6,500 Ha
  greenhouse (70%)
  open field (30%)



Nomisma/Unaproa 2014

New pathogens on leafy vegetables and year of first detection in Italy

New diseases	Basil	Lettuce	Cultivated rocket	Wild rocket	Lamb's lettuce	spinach	Leaf beet
Fusarium wilt	1989	2002	2003	2003		2014	
Verticillium wilt		2007					
Pythium spp.					2015	2014	2014
Phoma leaf spot		2010					
Alternaria leaf spot	2010	1968*	2011	2011			
Downy mildew	2004	1863*	2004	2004			
Plectosphaerella leaf spot	1978*			2012	2014		
Fusarium equiseti leaf spot		2014	2011	2014			
Myrothecium leaf spot		2015		2015	2015	2015	
Colletotrichum leaf spot			2014				

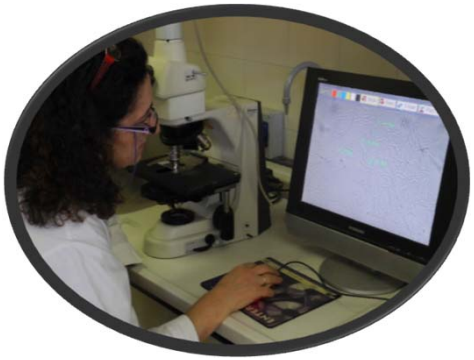
*Known since long time.

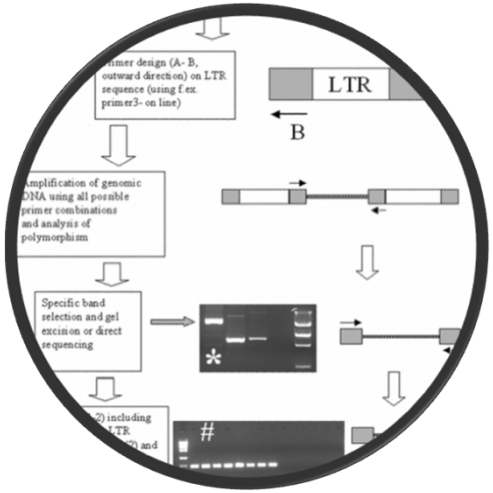
Factors driving emergence new pathogens

- ✓ **Intensive cultivation techniques** with 5-7 crops cycle in the same soil per year;
- ✓ **Seed-borne pathogens** introduced by seeds and propagation material. **High crop density (1,000 – 3,500 plants / m^2);**
- ✓ **Limited availability of chemicals**. More restrictions for minor crops and from the large-scale distribution.

Field surveillance and pathogens identification

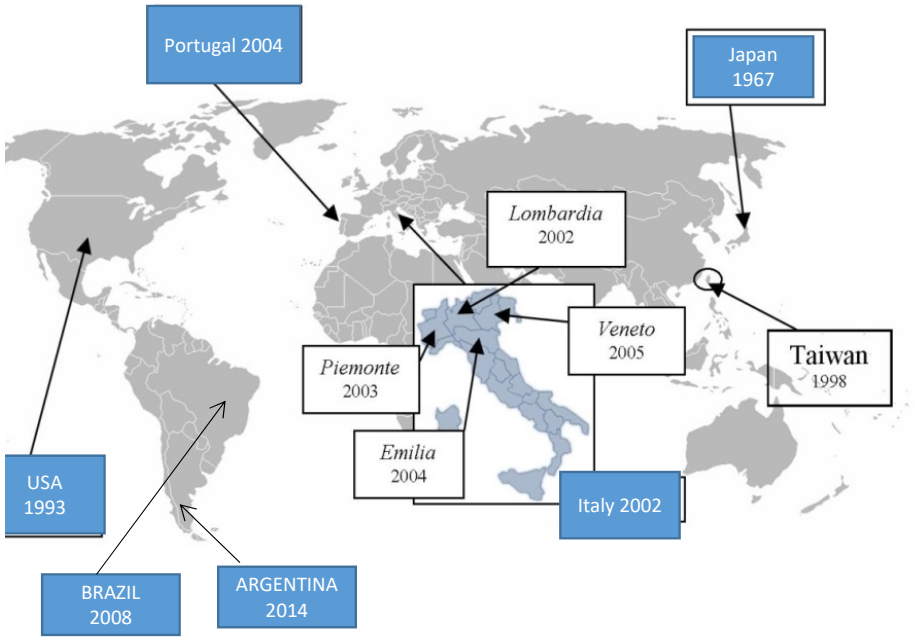
- **Field monitoring** (host, environmental conditions, disease severity…);
- **Isolation** in pure culture;
- **Pathogenicity test** to fulfill Koch's postulates;
- **Diagnostic tool**: Morphology, PCR with species-specific primers, sequence analysis of conserved genes, PCR-RFLP, or serology with species-specific antibodies.





Fusarium oxysporum f. sp. *lactucae* J.C. Hub&Gerik
Case study

- Japan (1967)
- California U.S.A. (1993)
- Taiwan (1998)
- Italy (2002)
- Arizona U.S.A. (2003)
- Portugal (2005)
- Brazil (2008)
- Argentina (2014)
- The Netherlands (2015)
- France (2016, personal communication CREAT France)



Fusarium wilt of lettuce is seed-trasmitted

Since 2009 included in the EPPO Alert List

Fusarium wilt of lettuce

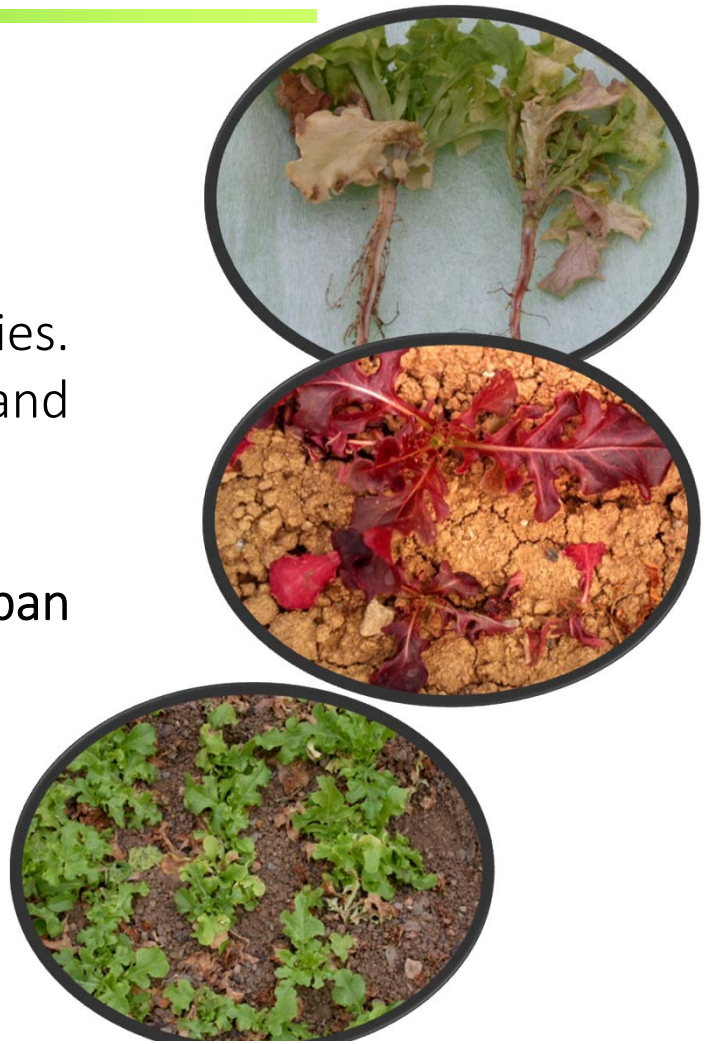
Fusarium oxysporum f. sp. *lactucae* (Race 1) Garibaldi *et al*., 2002

Fusarium wilt of lettuce: races distribution

Race 1 is present in Italy and other countries. Californian, Arizona, Japan, Taiwan (type 1) and Italian isolates belong to the same VCG.

Currently **races 2 and 3 are present only in Japan and Taiwan** (Fujinaga *et al*., 2005; 2014).

New **Race 4** in the Netherlands (Gilardi *et al*., 2016).



Alternaria leaf spot of wild and cultivated rocket

(Garibaldi *et al*., 2012)

Detected for the first time in Italy in 2011 on both wild and cultivated rocket.

Observed for the first time in California in 2014 on *Eruca sativa* soilless grown.

Host range: Most commonly occurring on radish cabbage and cauliflower.

Seed contamination: isolated only from not disinfected seeds of cultivated rocket (1 out 800 seeds) and from four out of ten samples of wild rocket (3 out of 800 seeds).

Disease management: seed dressing with chemicals and BCA's.

Plectosphaerella cucumerina leaf spot

Hosts and year of first detection in Italy: wild rocket (2012), endive (2012), lamb's lettuce (2014).

Known hosts: melon, watermelon, squash, zucchini, cucumber, sunflower, white lupin, tomato, basil, parsley.

Critical aspects

Seed contamination is confirmed: detected as seed contaminant of wild rocket. Four out of eight samples of rocket seeds were contaminated. Eleven isolates from 7,200 disinfected seeds tested, while none was isolated from an equal number of disinfected seeds.

Disease management: chemical control and resistant inducers.

Fusarium equiseti leaf spot

Hosts and year of first detection in Italy
Cultivated rocket (2011)
Wild rocket in southern Italy (2014)
Lettuce in northern Italy (2014)

Known hosts worldwide
Occurs in tropical and subtropical regions on cotton, lentil, sugar beet, cumin, potato, cowpea, pine, ginseng, asparagus.
Soil inhabitant, generally considered as a weak pathogen, can infect seeds, roots, tubers and fruit of several crops.

Critical aspects
- Associated with warm environments and wet conditions.
- Detected as seed contaminant on wild rocket and lettuce.
- Survival in soil and in plant debris between crops.
- Known for mycotoxins production (nivalenol, diacetoxyscirpenol, zearalenone).

Disease management: little information available.

Myrothecium leaf spot

Hosts and year of first detection in Italy
M. roridum: Lamb's lettuce (2015)
M.verrucaria: spinach (2015)
M.verrucaria: wild rocket (2015)

Known hosts in the World cotton, tomato, cacao, coffee, potato, soybean, cucurbits, on many ornamentals.

Seed contamination: ongoing evaluation.

Critical aspects
- Large distribution because of its broad host range and because is a facultative parasite of numerous plants.
- Favored by climate change (increase in temperatures and the need of a very short period of leaf wetness).

Disease management: little information available.

Myrothecium verrucaria on spinach

Myrothecium roridum on lamb's lettuce

Myrothecium verrucaria on wild rocket

Field surveillance: new foliar pathogens in Italy in 2012-2016

- ***Fusarium equiseti***

  Cultivated rocket, 2011

  Wild rocket,2014

  Lettuce, 2014
- ***Alternaria japonica***

  Wild and cultivated rocket, 2011
- ***Colletotrichum kahawae***

  Cultivated rocket, 2014
- ***Myrothecium roridum***

  Lamb's lettuce, 2015
- ***Myrothecium verrucaria***

  Spinach, 2015, wild rocket 2015

Looking to possible seed contamination

Contamination of lettuce, endive, cichory, rocket, corn salad, spinach, and basil seeds by various fungal pathogens

Crop	Pathogen	% of infected seeds	Reference
Lettuce	*Fusarium oxysporum f. sp. lactucae*	0.1	Garibaldi et al. 2004
Lettuce	*Verticillium dahliae*	66-90	Vallad et al. 2005
Lettuce	*Botrytis cinerea*	30	Sowley et al. 2010
Lettuce	*Microdochium panattonianum*	*	Sutton and Holderness, 1986
Endive, cichory, escarole	*Alternaria cichorii*	0.6-13.75	Barreto et al. 2008.
Endive and cichory	*Microdochium panattonianum*	*	Sutton and Holderness, 1986
Rocket	*Fusarium oxysporum*	0.1	Garibaldi et al. 2004
Wild rocket	*Plectosphaerella cucumerina*	0.15	Gilardi et al. 2013
Corn salad	*Phoma valerianellae*	0.6 – 15	Pellegrino et al. 2010
Basil	*Fusarium oxysporum f. sp. Basilici*	0.4 (external contamination) 0.2 (embrio contamination)	Martini and Gullino 1991
Basil	*Alternaria alternata*	0.2-15.0 (external contamination) 0.2-2.0 (embrio contamination)	Gilardi et al. 2012
Basil	*Peronospora belbahrii*	0.01	Garibaldi et al. 2004
Wild and cultivated rocket	*Alternaria japonica*	0.1-3.0 (external contamination)	Gilardi et al., 2015
Wild rocket	*Fusarium equiseti*	0.1-3.0 (external contamination)	Gilardi et al., 2016

*Not available.

Control measures: where research is focused…

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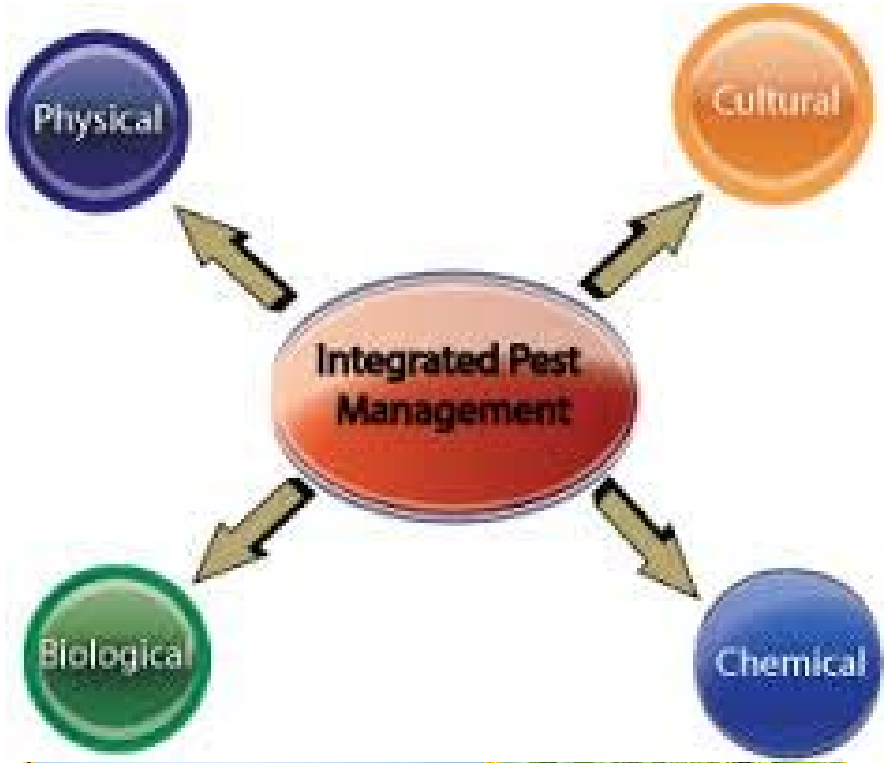
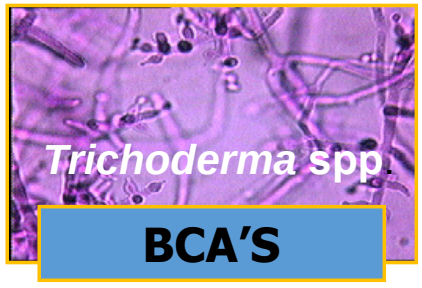
I. Varietal resistance
II. Seed health and seed dressing
III. Biocontrol agents (BCA'S)
IV. Biofumigation
V. Suppressive soil
VI. Resistant inducers (SAR)
VII. Physical soil disinfestation
VIII. Sustainable application of fumigants





BCA'S

Solarization

Biofumigation

Summary

- A relatively small percent of contaminated seeds is sufficient to introduce new pathogens.
- Rocket seeds are a potential source of inoculum for *Plectosphaerella cucumerina*, *Alternaria japonica* and *Fusarium equiseti.*
- Fusarium wilt of lettuce is endemic in several growing areas in Italy. Risk for the introduction/selection of new races.
- Increased introduction of pathogens that are typical of warm climate (i.e. *Myrothecium* spp. and *Fusarium equiseti).*
- Need for rapid changes in disease management and good extension services.

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Looking at the future

- Using pathogen-free propagating material.
- Improving the accurancy and speed of field and laboratory diagnostic methods.
- Identifying the primary source of inoculum.
- More investments in research, extension services and education.

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Thanks! ☺