Seed-borne fungal pathogens of vegetable crops

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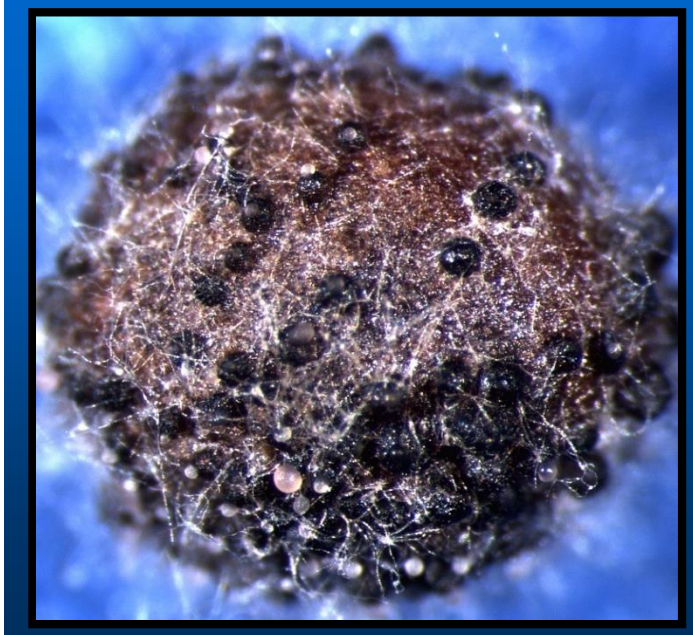
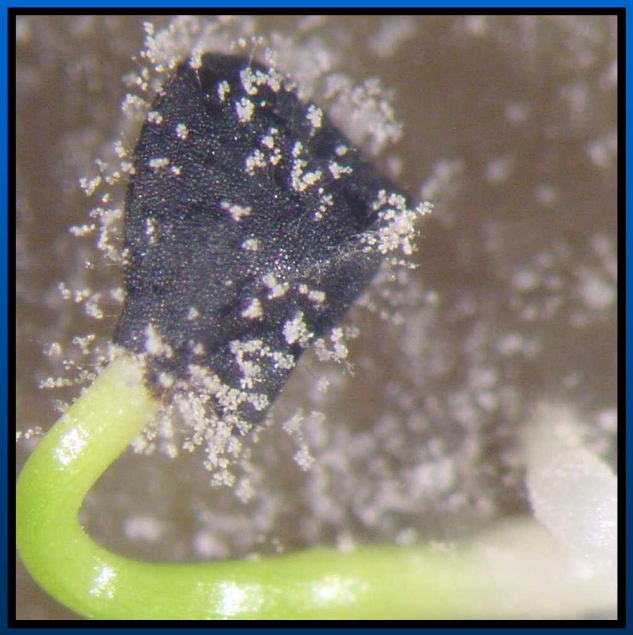
International Workshop on Seedborne Diseases of Vegetable Crops
Hyderabad, India June 2-5, 2014


borne Pathogens of Vegetable Crops

- Long distance spread of new pathogens or races of pathogens
- Low rates of infection -0.01% can result in nearly 100% infection in densely planted transplant beds or greenhouse seedling production
- Management depends on seed producer
  - Seed production field
  - Detection
  - Seed treatments

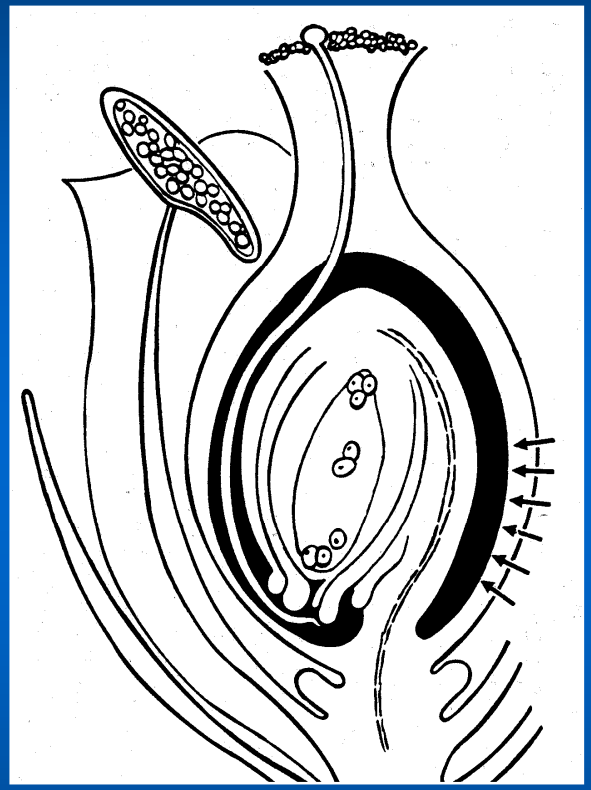
Gummy stem blight of melon

Seed-borne vs. seed transmitted organisms

- Gain access to seed
  - Active infection with in seed
  - Passive-on seed surface or contaminant
- Survive commercial processes
  - Harvest, cleaning, treatment, storage
- Establish on emerging seedlings
  - Primary or secondary transmission

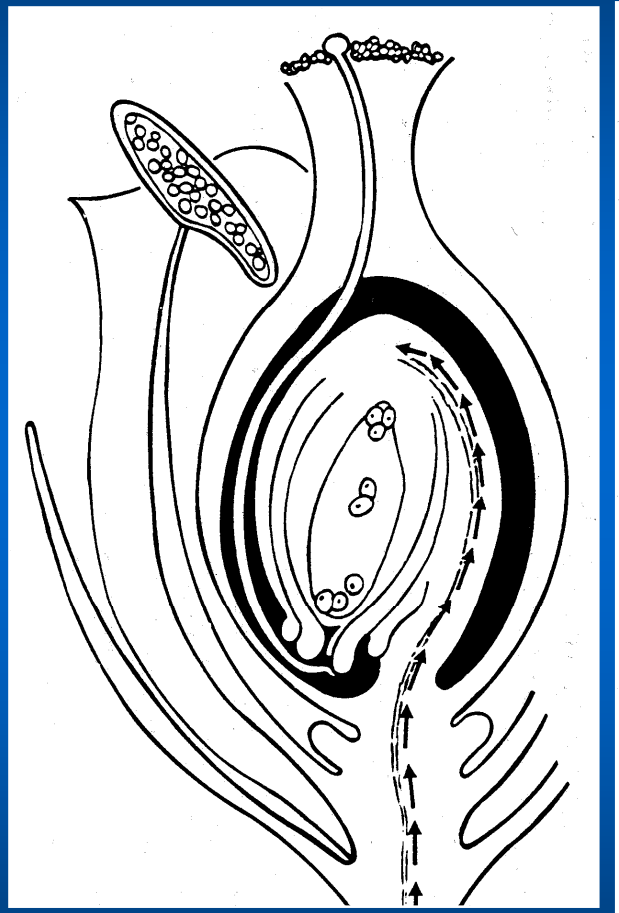
f active seed infection

A. Penetration through ovary wall



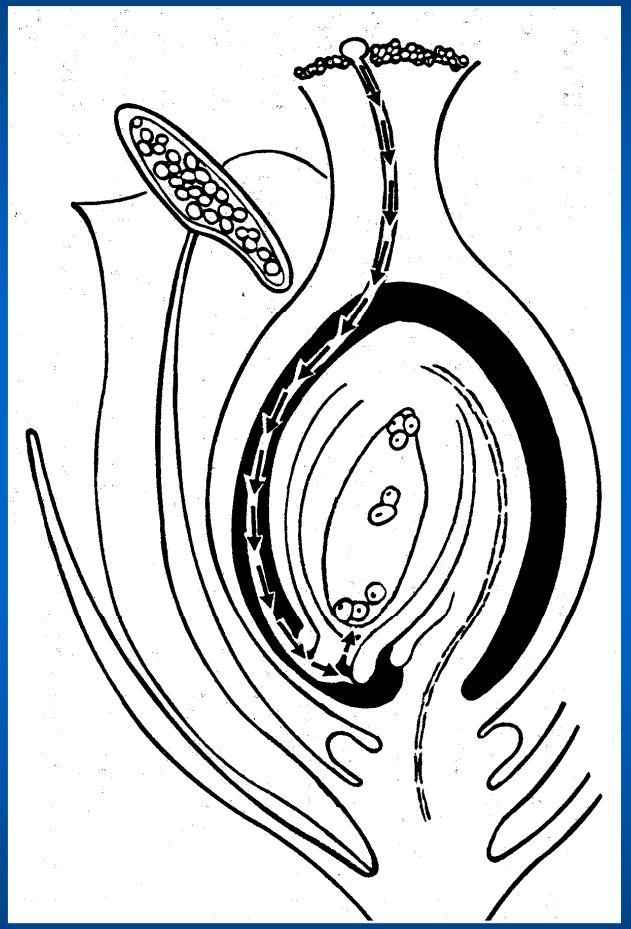
E.g.: *Botrytis aclada, B. allii* (onion)
Cladosporium variabile (spinach)

B. Systemic infection via vascular system



E.g.: Vascular wilt fungi, endophytes

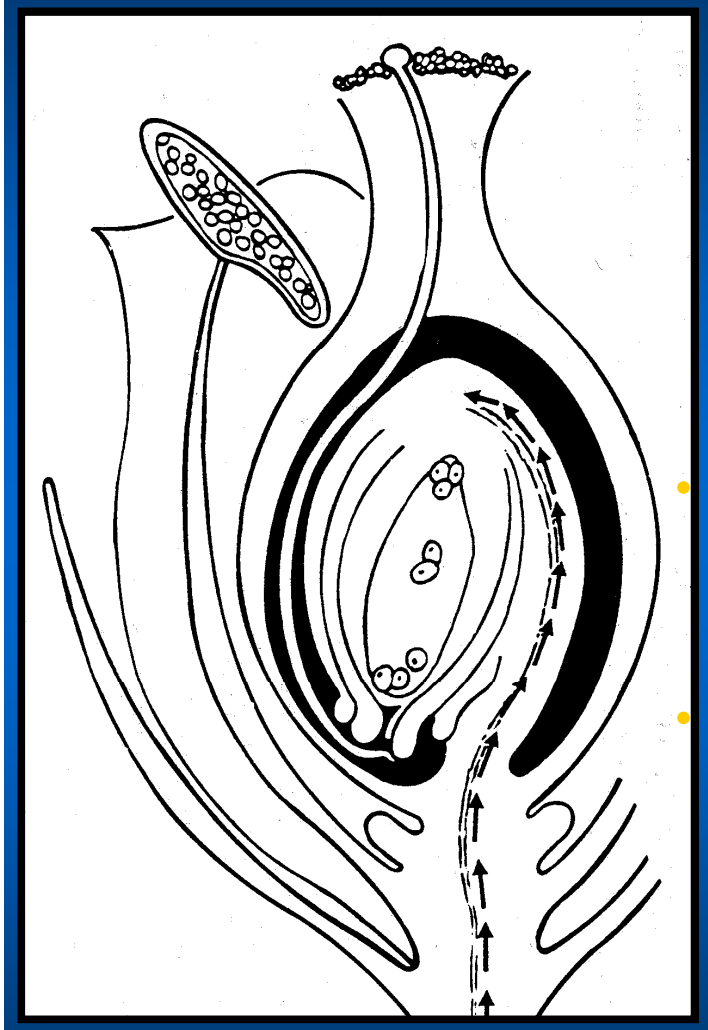
C. Penetration through floral parts



E.g.: *Ustilago nuda* (grains)
Cucumber mosaic virus

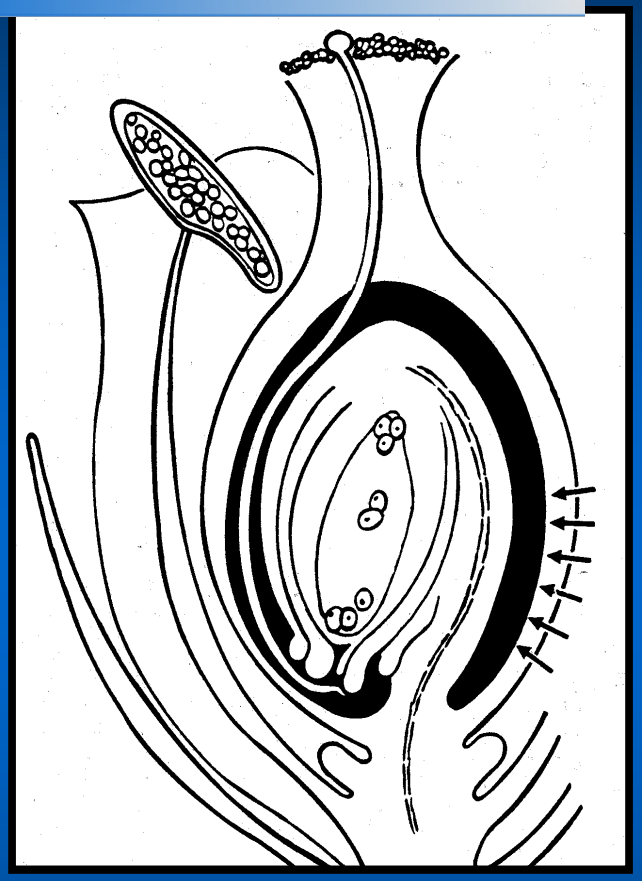
From Maude (1996)

...ic infection via vascular system

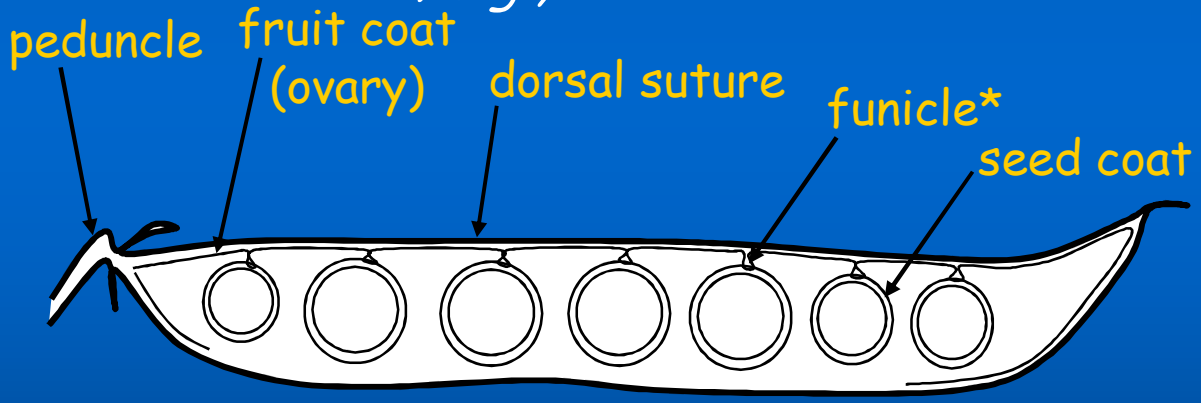


- Some fungi, e.g.:
  - Vascular wilts (*Verticillium dahliae*, *Fusarium oxysporum*)
  - some downy mildews
-
- Direct connection between embryonic & endospermic tissue becomes disconnected as seed develops
- Potential for transmission affected by degree of internal infection

fection via flower or fruit



- Weak necrotrophs:
  - *Botrytis cinerea* - infected petals remain attached to developing fruit
- Aggressive necrotrophs:
  - Attack floral parts directly
  - e.g., *Ascochyta pisi*, *Alternaria brassicicola* , *Leptosphaeria maculans*, *anthracnose fungi, etc*



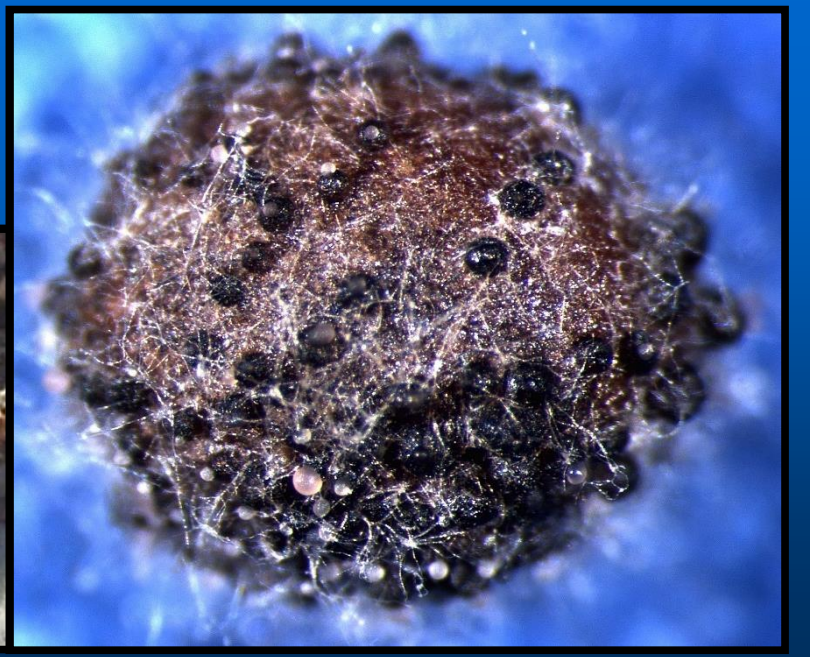
- Fleshy fruits (e.g., Solanaceae) – seed attached to central placenta - infect via calyx - placenta – funicle – embryo
- Umbelliferae & Liliaceae – flowers exposed in umbels
- Seed transmission is typically discontinuous (infection outside embryo) - affected by environmental conditions

Brassica seed

Alternaria brassicicola & *A. brassicae*

Correlation of severity of pod spot with:
Seed germ = -0.89, Seed rot = +0.88

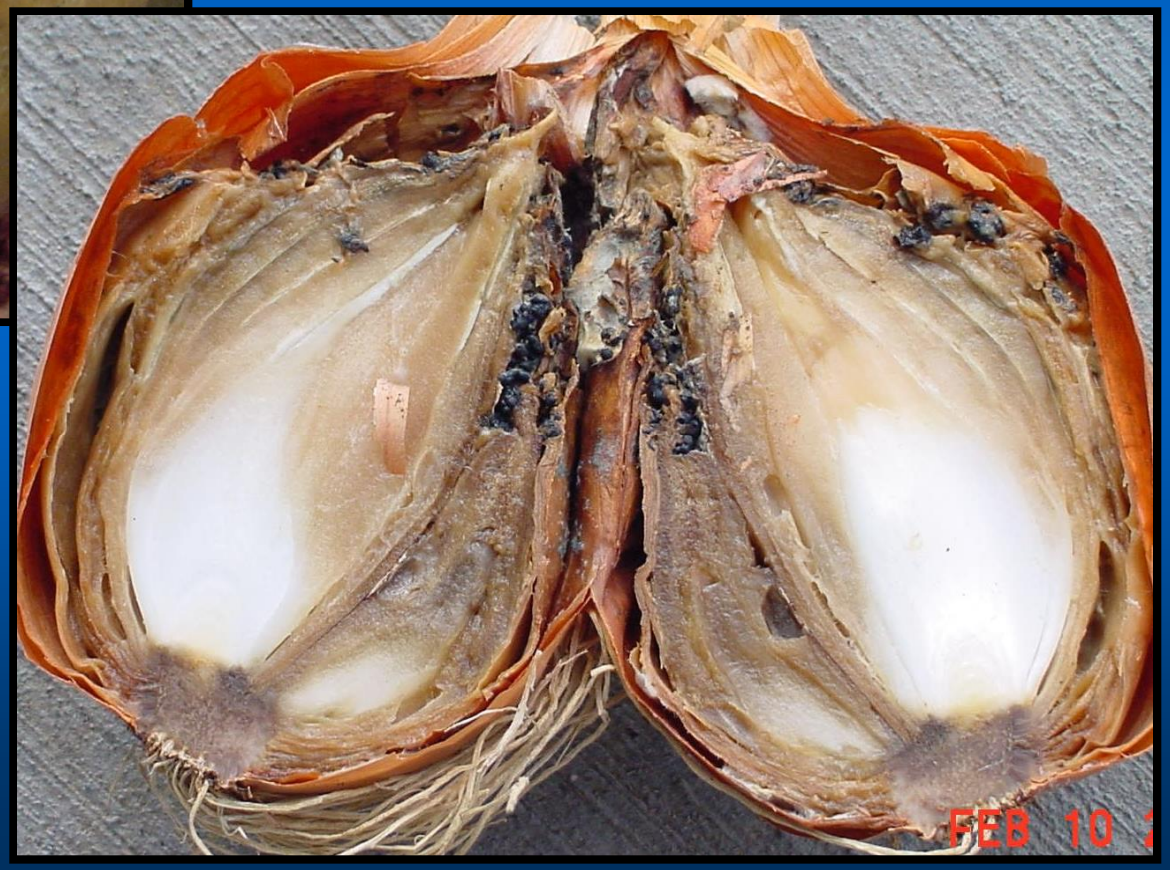
du Toit & Derie, 2003. Fung. & Nem. Tests 58:V026



Leptosphaeria maculans

Botrytis scape & flower blight of onion: *B. acladal B.allii*
B. squamosa
B. byssoidea

Seedborne *Botrytis aclada* & *B. allii* in onion



gal Seed-borne Pathogens

- Alliaceae-Onion/Leek
  - Botrytis neck rot- Botrytis aclada
- Amaranthaceae- Beet/Swiss chard
  - Phoma damping-off/canker-Phoma betae
  - Downy mildew- Peronospora farinosa f.sp. betae
- Amaranthaceae- Spinach
  - Downy mildew- Peronospora farinosa f.sp. Spinaciae
  - Fusarium wilt- Fusarium oxysporum f.sp. Spinaceae
  - Verticillium wilt- Verticillium dahlia
  - Anthracnose- Collectotrichum dematatium
  - Cladosporium leaf spot-Cladosporium variabile
  - Stemphyllium leaf spot-Stemphyllium botryosum
  - White rust- Albugo occidentalis

Major Fungal Seed-borne Pathogens

- Apiaceae-Carrot/Parsnip
  - Black rot/Black crown-Alternaria radicina
  - Alternaria leaf blight-Alternaria dauci
  - Cercospora leaf blight-Cercospora carotae
  - Similar pathogens on Celery/Parsley/Cilantro
- Asteraceae-Lettuce
  - Septoria leaf spot- Septoria lactucae
- Brassicaceae-cabbage, etc
  - Black leg- Leptosphaeria maculans (Phoma lingam)
  - Black spot- Alternaria brassicola
  - Alternaria leaf spot-Alternaria brassicae
  - White rust-Albugo candida

Major Fungal Seed-borne Pathogens

- Cucurbitaceae-Cucumber/Squash/Melon
  - Fusarium crown and foot rot-F.solani f.sp. cucurbitacae
  - Gummy stem blight- Didymella bryoniae
- Solanaceae-Tomato
  - Ditymella stem rot-D. lycopersici
  - Early blight-Alternaria tomatophila/solani
  - Fusarium crown and root rot-F. oxysporum f.sp. radices-lycopersici
  - Fusarium wilt-F. oxysporum f.sp. Lycopersici
  - Late blight- Phytophthora infestans
  - Phoma rot- P. destructive var destructive
  - Septoria leaf spot- S. lycopersici

Major Fungal Seed-borne Pathogens

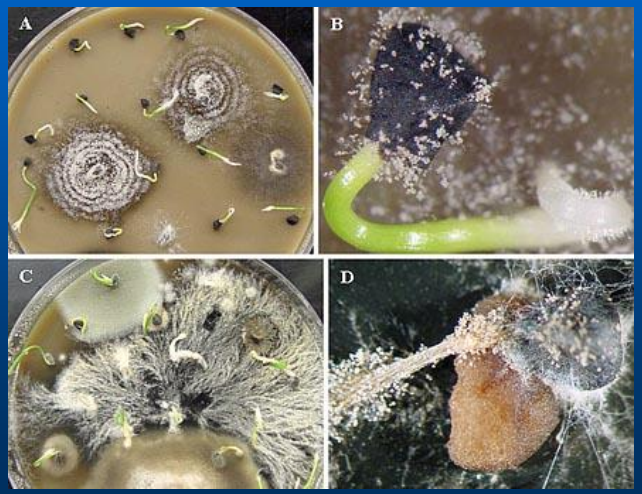
- Malvaceae-Okra
  - Anthracnose-Colletotrichum dematium
  - Foot and root rot-Fusarium oxysporum
  - Corynespora leaf spot-C.cassicola
- Solanaceae-Eggplant
  - Anthracnose-Colletotrichum sp.
  - Phomopsis fruit rot- P. vexans
- Solanaceae-Pepper/Chili
  - Anthracnose-Colletotrichum sp.

ment-Seed Producer

- National/International Quarantine Rules
- Seed Production Field selection
  - Produce seed in low rainfall areas- avoid overhead irrigation- many pathogens are dispersed by splashing water
  - Use plastic mulch/trellis to keep fruit off soil
  - Appropriate crop rotation/ weed host control
  - Avoid field with history of persistent soil pathogens such as Fusarium/Verticillium wilt fungi

Management-Seed Producer

- Plant pathogen free seed in seed production field
  - indexed for pathogen (culture, visual, ELISA, PCR)
    - Amount of seed tested determined by allowable threshold- need better research
  - Hot water treatment
  - Fungicide treatment
  - Other treatment-essential oils, biologicals



reatment for freeing seed of bacterial and fungal infection

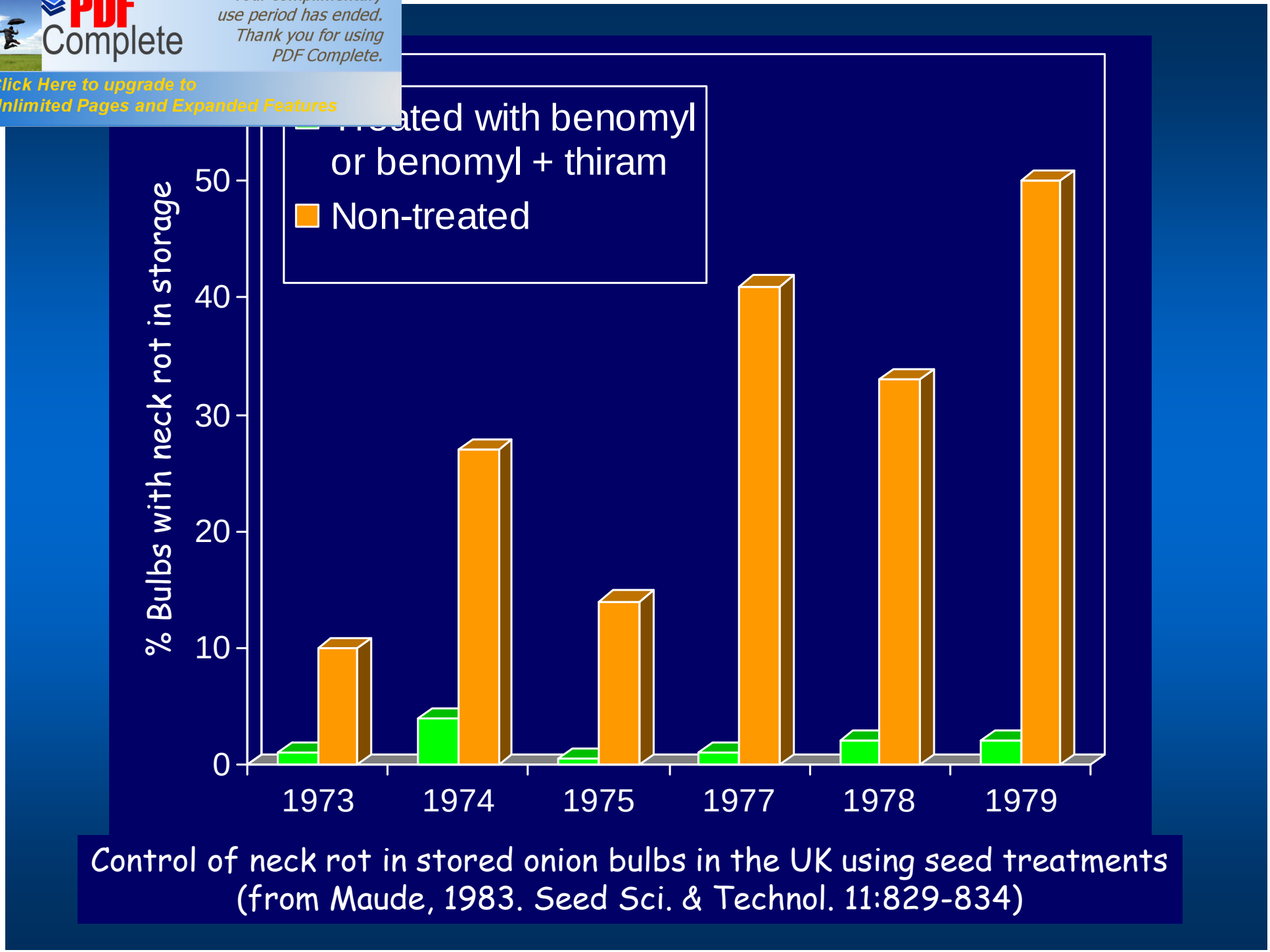
- May be deleterious to ñweak seedò- test small sample first
- May reduce seed storage life
- Need precise temperature control
- Cannot use on cucurbit/legume seeds
- Amaranthaceae-20-25 min @ 50-52 ^{0}C
- Apiaceae-20 min @ 50 ^{0}C
- Asteraceae-30 min @ 48^{0}C
- Brassicaceae-20-25 min @ 50 ^{0}C
- Solanacease 25 min @ 50 ^{0}C

Other Physical Methods

- Aerated steam
  - Forsberg et al., 2002. J. Plant Diseases and Protection 109: 357-370
  - Amein et al., 2011. J. Plant Diseases and Protection 118: 214-221
- Microwave (electron)
  - Tinivella et al., 2009. European J. Plant Pathology 123: 139-151
  - Amein et al., 2011. J. Plant Diseases and Protection 118: 214-221

Fungicide and other treatments

- Fungicide treatments
  - Seed soaks – Thiram/systemic fungicides (benzimidazole, triazole, SDHI, QoI (strobilurin))
  - Traditional seed treatments-systemic fungicides
- Other
  - Use of essential oils – Thyme oil,garlic oil, etc
  - mycofumigation- Muscodor albus
  - Bleach, peroxyacetic acid, chlorine dioxide or other disinfectants
  - Biopesticides-Bacillus sp., Pseudomonas sp., Trichoderma sp., Streptomyces sp.- many commercial products



Control of neck rot in stored onion bulbs in the UK using seed treatments
(from Maude, 1983. Seed Sci. & Technol. 11:829-834)

elative efficacy

Pathogen	Fungicide	Physical means	Plant Extracts /oils	BCA	BCA + Oils
Carrot Alternaria dauci	+++	+/+++	++	+/++	?
Cabbage Alternaria	+++	+/+++	++	++	++
Cabbage Black leg	+++	+/+++	++	-/++	++
Tomato Fusarium wilt	+++		++/+++	++	++
Legume Ascochyta	+++	-	++	+	

+++ >80%, ++=50-80%, +=20-50%

Pest Management Science 70:860-868 2014.

Management-Seed Producer

- Use appropriate fungicide/insecticide programs on seed crop
- Visual inspection of seed production field for sign/symptoms of disease
- Timely harvest
- Seed cleaning- remove contaminating pathogens
- Seed testing for pathogen infection
  - Int.Seed Health Initiative-Veg-2002 Seed Health Testing Methods Reference Manual
  - ISTA-Manual for Seed Health Testing Methods
    - I-Validated Test Methods
    - II Peer Reviewed Methods

Reference websites

With new technologies methods change rapidly

- International Seed Testing Association
  - http://www.seedtest.org/en/home.html
- International Seed Health Initiative
  - http://www.worldseed.org/ifs/ishi.html

Management Transplant/Seedling Producer

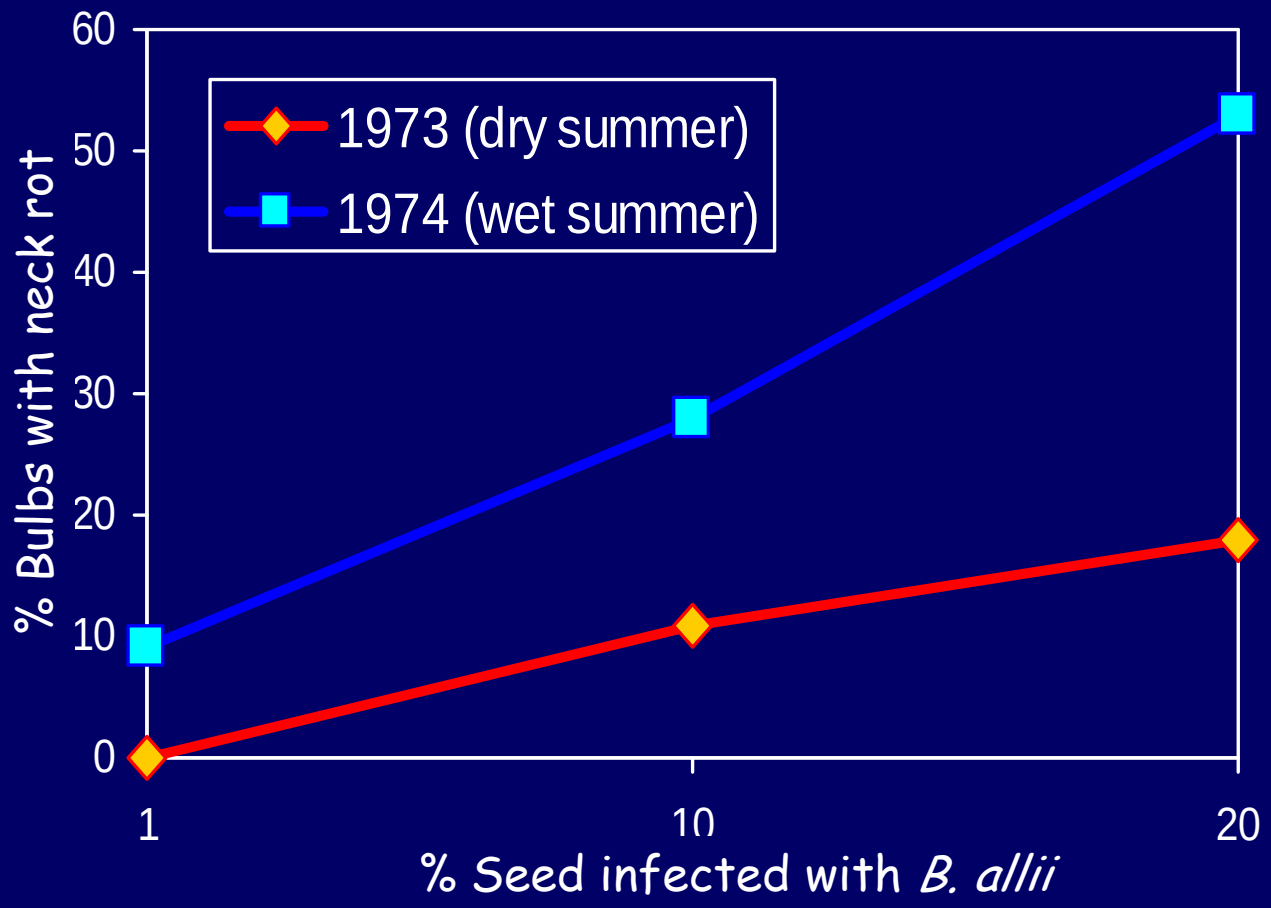
- Purchase only high quality seed with appropriate treatment
- Use Bacillus, Pseudomonas, Trichoderma seed soil treatments
- Avoid splashing water during irrigation-fine mists or use watering mats
- Do not work amongst or handle wet plants
- Scout regularly for signs of damping-off, leaf blights, etc-remove and isolate
- Use appropriate fungicide sprays-fungicide resistance management
  - azoxystrobin/Gummy stem blight melon

for seed transmission

- Environmental factors- seed production field
  - temperature*
  - moisture*- many seedborne pathogens are water splash disseminated-avoid overhead irrigation, low rainfall areas
  -degree of internal infection of seed
- Genotype
  - host resistance, maternal vs. paternal
  - pathogen isolate/strain
- Inoculum potential
  - amount of inoculum & conduciveness of environment
  - transmission rate
  - threshold(s) for seedborne inoculum
  - complex, lack of adequate field research

environment on seed transmission of *rytis acladal B. allii* in onion

Tichelaar, 1967; Maude & Presly, 1977a



Relationship between infected onion seed & post-harvest neck rot in the UK (from Maude & Presly, 1977b)

Ellerbrock & Lorbeer (1977): Field infection sources were more important in NY than infected seed.

Seedborne pathogens: Implications for risk analysis

- Epidemiology of the pathogen
  - Potential for seed transmission
  - Conditions for disease development & spread
  - Ease of eradication
- Alternative sources of inoculum
  - Infested residues
  - Soilborne inoculum
  - Infected adjacent or overwintering crops or weeds
- In-field control measures
  - Resistant cultivars
  - Fungicides & forecasting
  - Crop rotation
  - Plant spacing, row orientation, direct seeding
  - Irrigation (system & schedule)
- Threshold(s) for seedborne inoculum
  - Environmental conditions?
  - Resistant vs. susceptible cultivars?

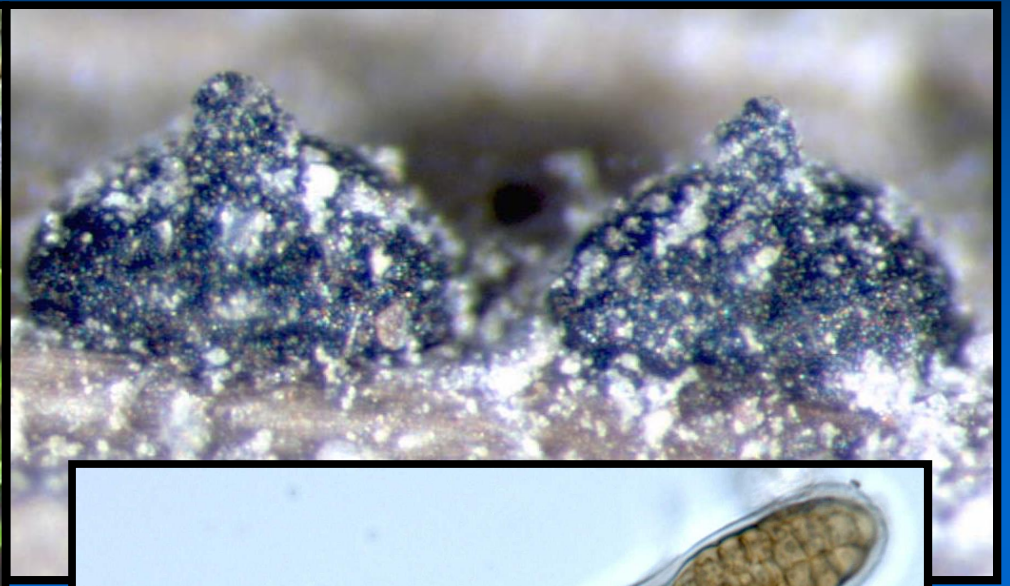
e pathogens: Implications

Alternative inoculum sources for seedborne carrot diseases

- Infested residues (*Alternaria dauci* in CA) (Gilbertson et al.)
- Soilborne inoculum (*Alternaria radicina* = 8 years)
- Infected adjacent or overwintering crops or related weed hosts (*X. campestris* pv. *carotae* in carrot seed crops in PNW)

du Toit et al., 2005. Plant Dis. 89:896-907.

urces of inoculum for *Stemphylium* *osum* in spinach seed crops



Overwintering fruiting bodies only on residues on soil surface

du Toit & Derie, 2003. Phytopathology 93:S22

ges presented by seed borne pathogens

- Determine **definitively** if a seedborne pathogen is seed transmitted?
- Develop thresholds for seedborne inoculum, applicable to a range of environments?
- Regulatory implications for seed transmitted vs. seedborne status?