Effects of Flooding on Soilborne Potato Pathogens in the Skagit in the Skagit Valley of Western Washington

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The Nature Conservancy
&
Washington State University

Main project components in 2010...

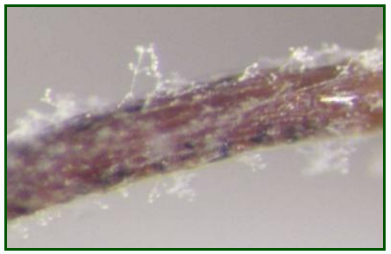
- Survival of sclerotia of *Sclerotinia sclerotiorum*
- Survival of microcslcerotia of *Verticillium dahliae*
- Container assays in greenhouse and/or temperature-controlled growth chambers
- NWREC microplots in *Verticillium* infested field (flooded or fallowed in 2009; potatoes in 2010)
- ‘Shameful six’ study on soil survival
- Potato pathogenicity verification in greenhouse
- Cooperated with TNC on the on-farm trials

Soilborne fungal pathogens are good candidates for exploring flooding as a method of pathogen *eradication*

- Specialized propagules may persist many years in soil in a dormant state, allowing for over-wintering and long-term survival

  -- *Fusarium* macroconidia/chlamydospores, several years
  -- *Phytophthora* and *Pythium* oospores, several years
  -- *Rhizoctonia* sclerotia, 1-2+ years
  -- *Sclerotinia* sclerotia, 3+ years
  -- *Spongospora cystosori,* 6-10+ years
  -- *Streptomyces* spores, indefinitely
  -- *Verticillium* microsclerotia/melanized hyphae, 5-10+ years

- Dormant propagules are able to infect plant tissue once a potato crop begins to develop, and soil conditions are favorable



Formation of conidia & systemic colonization of vascular system

Chlorosis, necrosis, and wilting of foliage

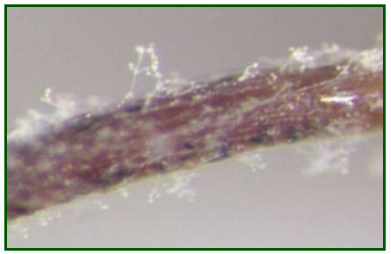
Colonization of senescing plant tissue and development of microsclerotia in dead tissues

Plant residues along with infective propagules are incorporated into soil

Infective propagules germinate as susceptible plants develop

Colonization of root cortex and entry into xylem vessels

- Generally, only one cycle of infection, pathogen growth and reproduction per growing season



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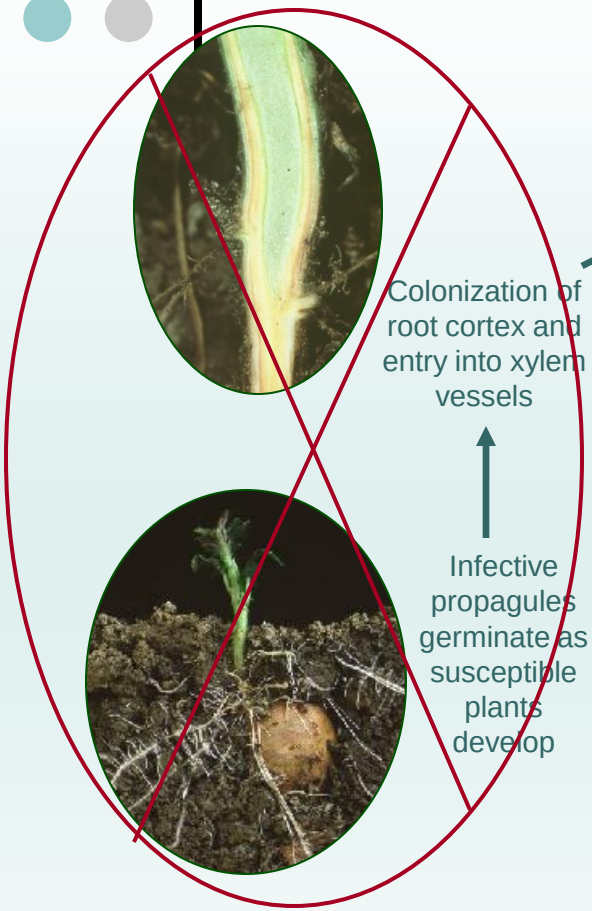
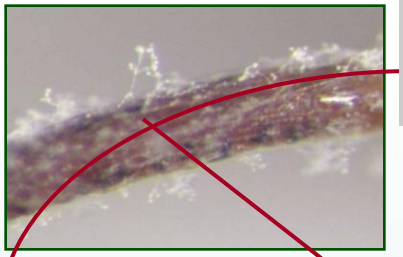


Colonization of root cortex and entry into xylem vessels

Exclusion to reduce the number of introduced propagules

Plant protection to limit the number of infections per plant



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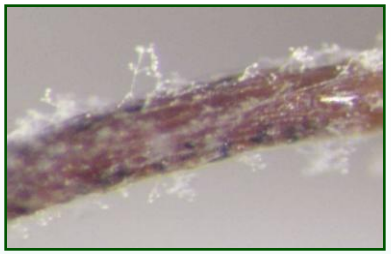

Formation of conidia & systemic colonization of vascular system

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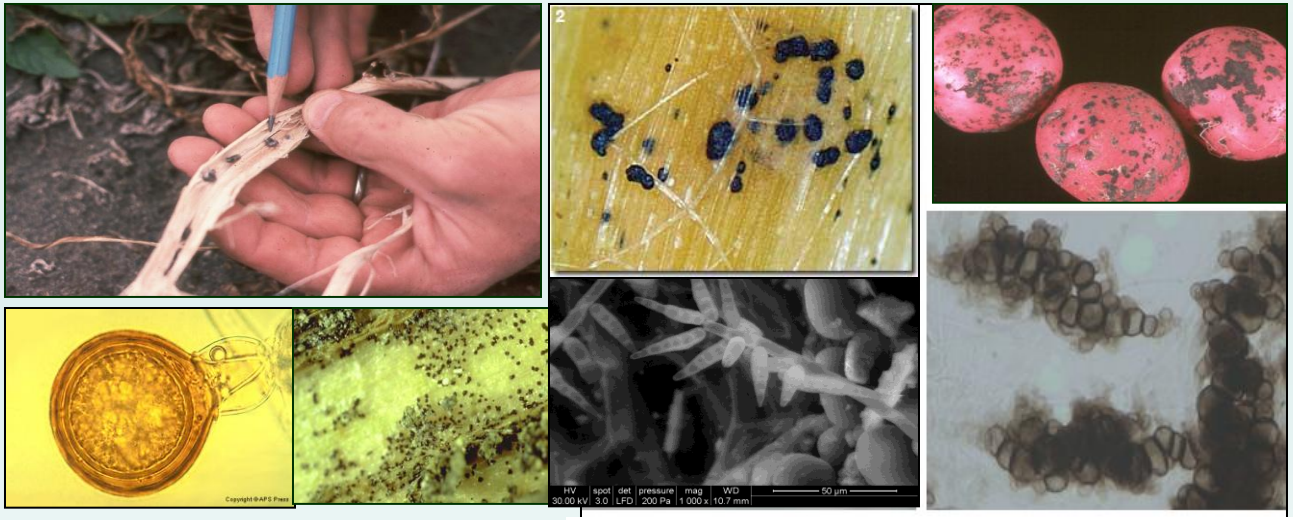
Colonization of root cortex and entry into xylem vessels

<u>Eradication</u> to eliminate soil populations

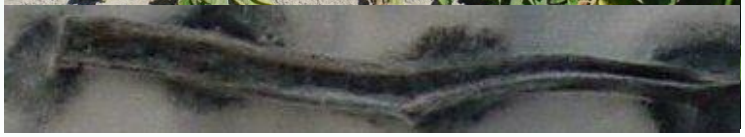
Sclerotinia (white mold*; Colletotrichum* (black dot); *Rhizoctonia (*black scurf); *Pythium* (leak); *Verticillium* (Vert wilt); *Helminthosporium* (silver scurf); *Fusarium* (dry rot) among others...



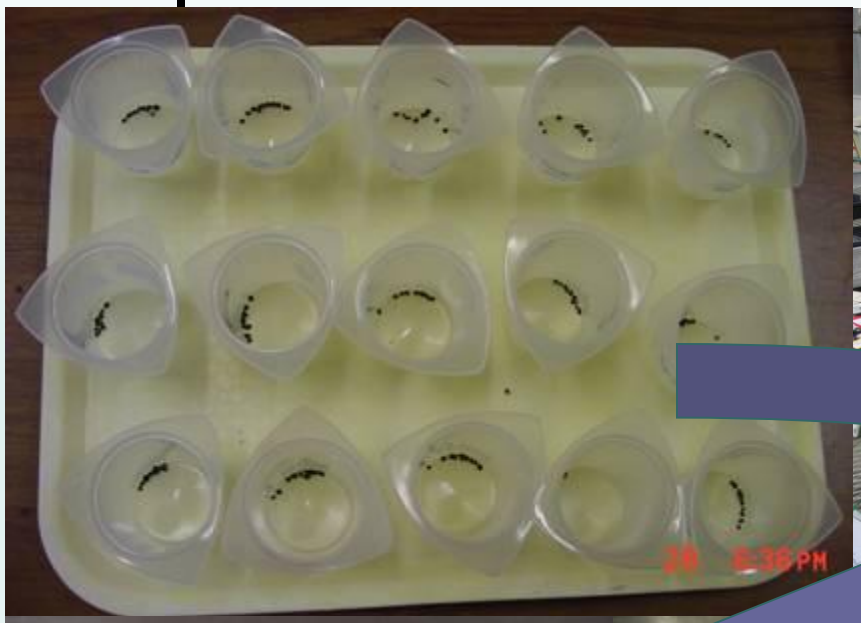
Some potato fungal pathogens in Skagit Valley

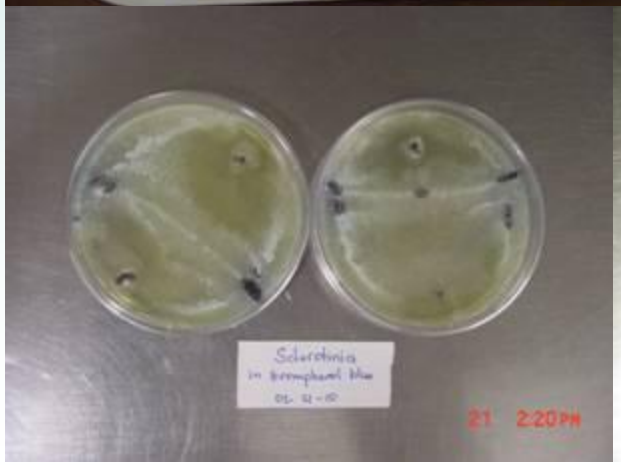
Sclerotinia stem rot (white mold)

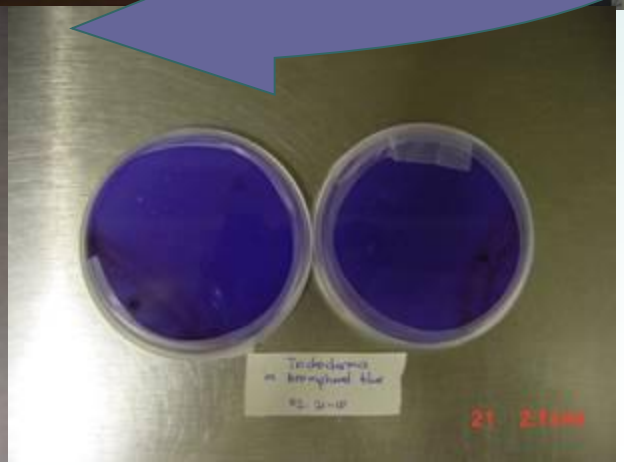
Verticillium wilt (potato early dying)



Sclerotinia greenhouse tests in cone-tainers

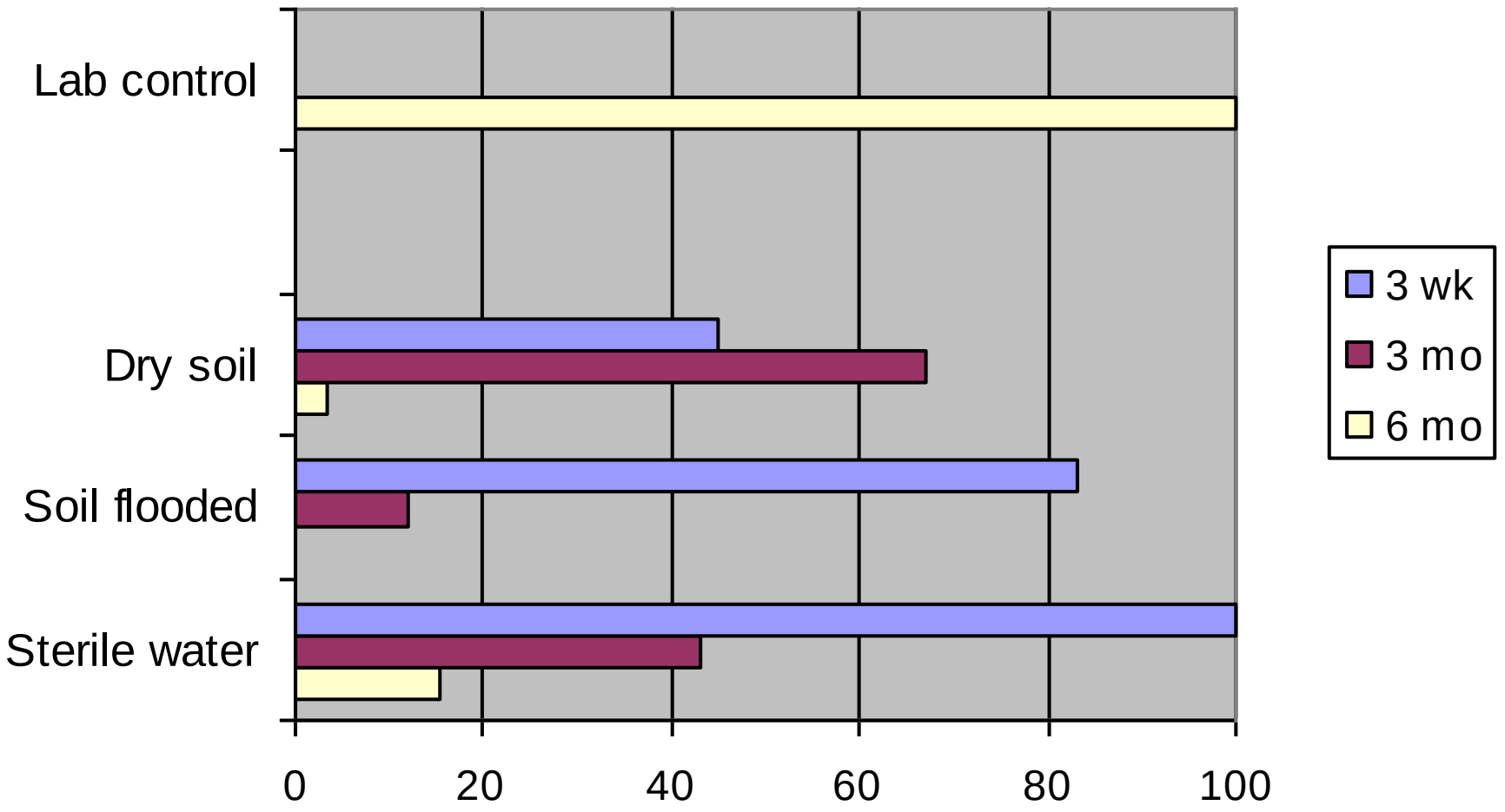






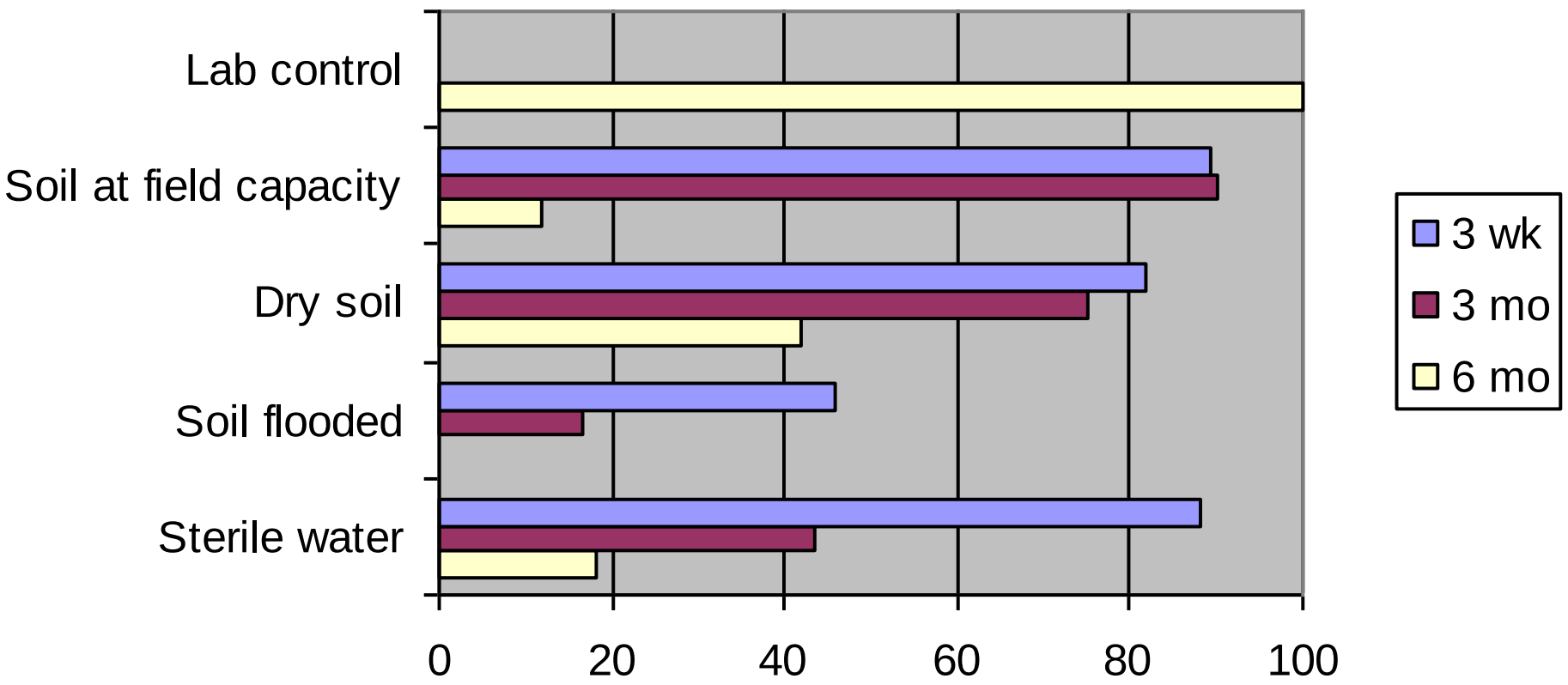
- 6 reps/treatment
- 10 sclerotia/cone
- 1-2 sclerotia/plate
- BPB / PDA media

% Germination of *Sclerotinia* sclerotia, Greenhouse test 09-1



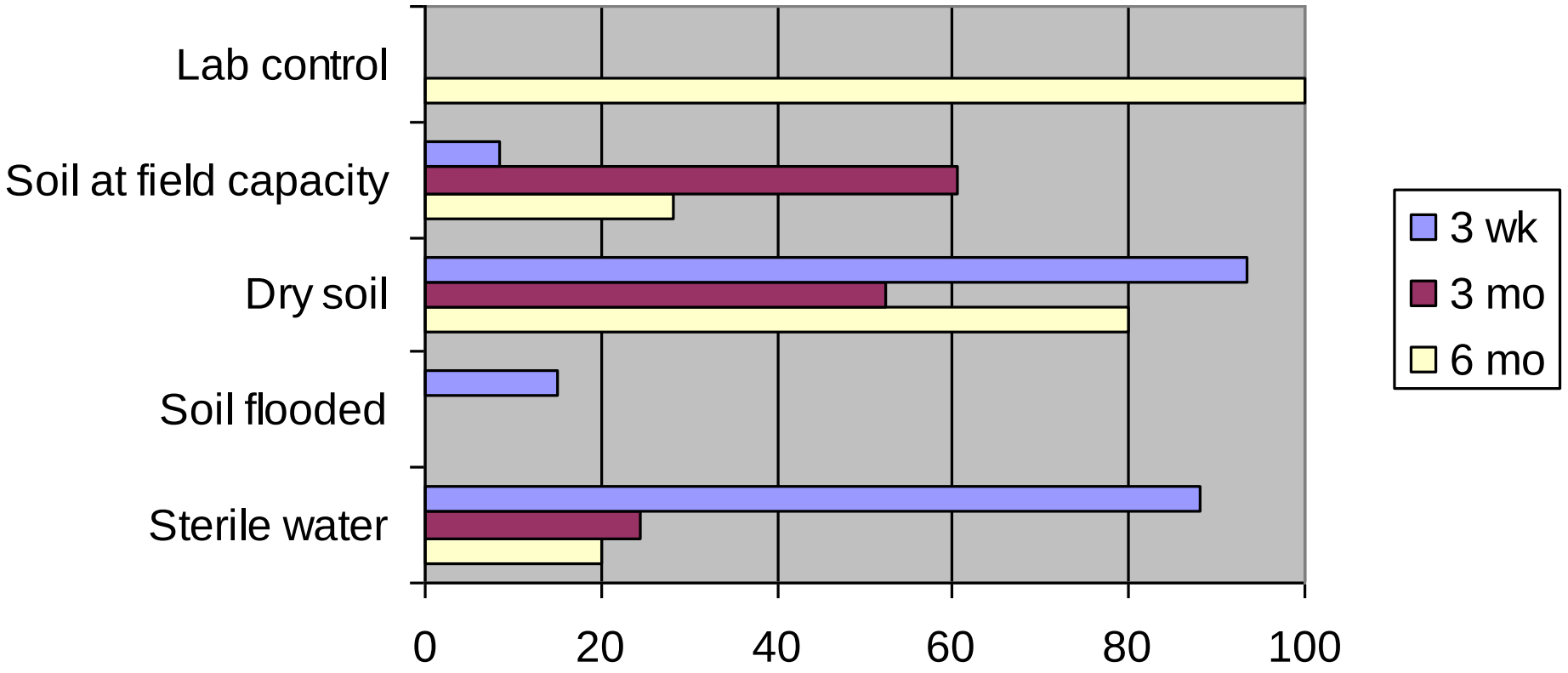
Sclerotia harvested from PDA plates on 7/21/09

% Germination of *Sclerotinia* sclerotia Greenhouse test 09-2



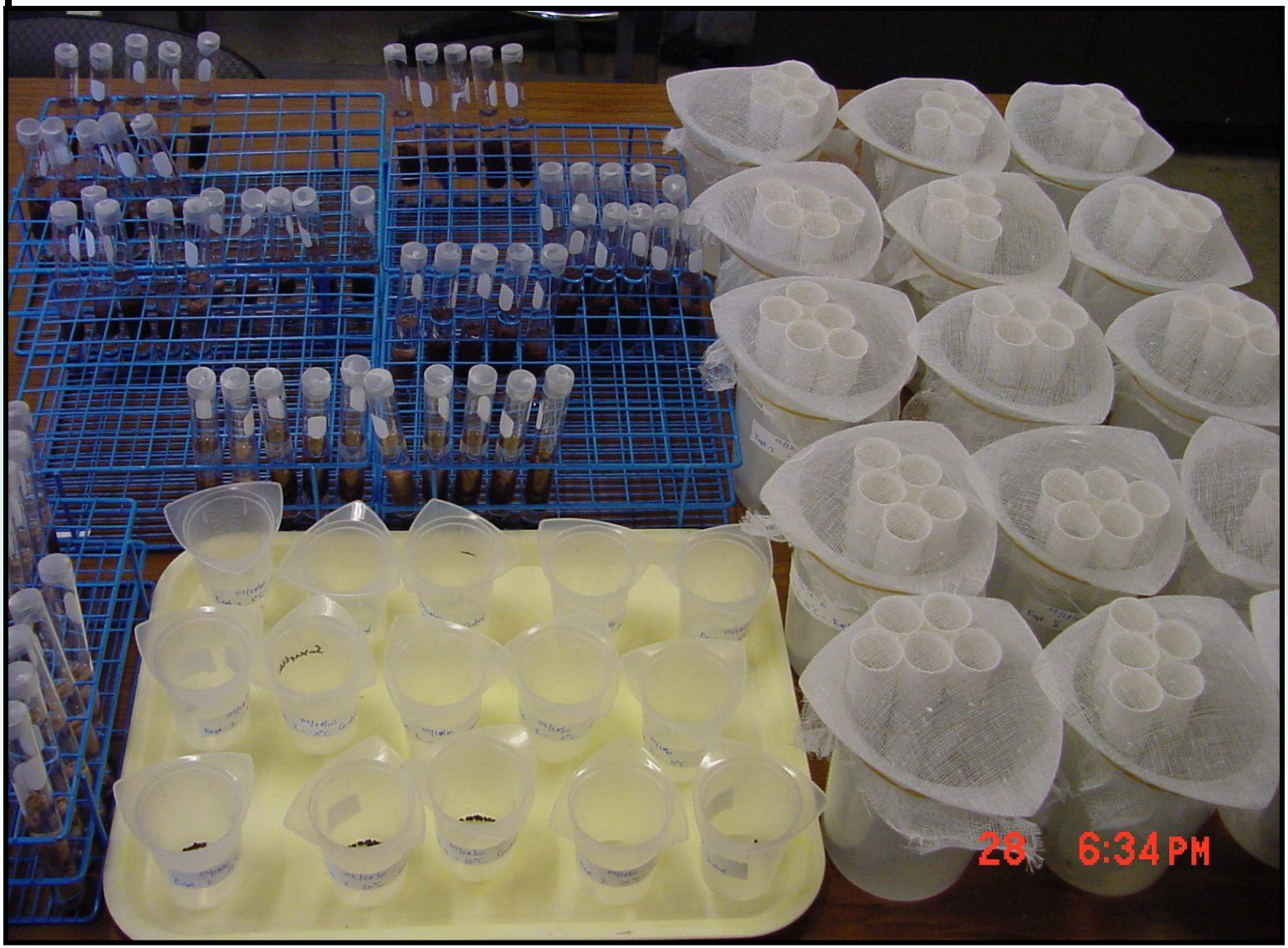
Sclerotia harvested from PDA plates on 7/21/09

% Germination of *Sclerotinia* sclerotia Greenhouse test 09-2R

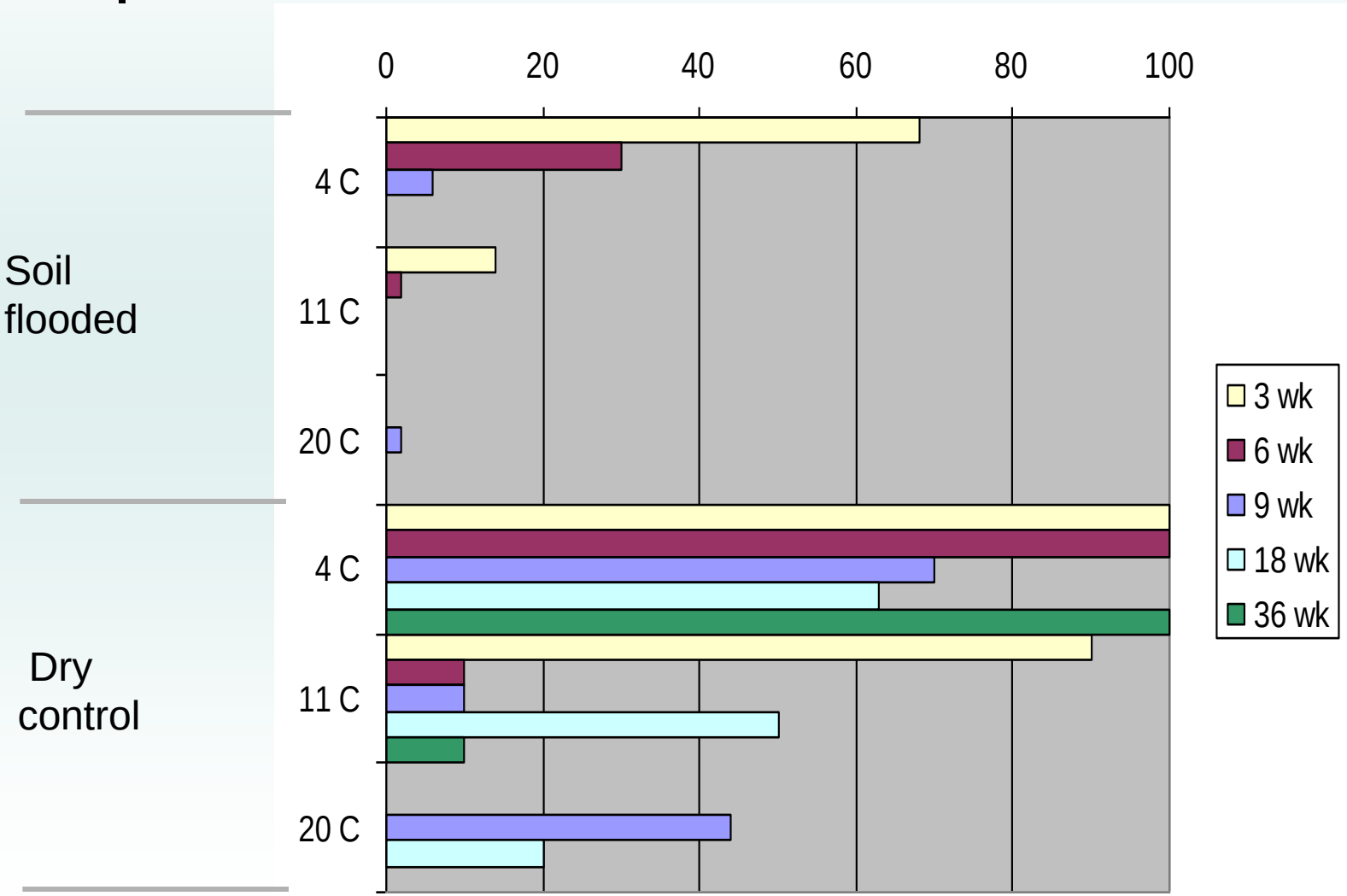


Sclerotia harvested from PDA plates on 8/5/09

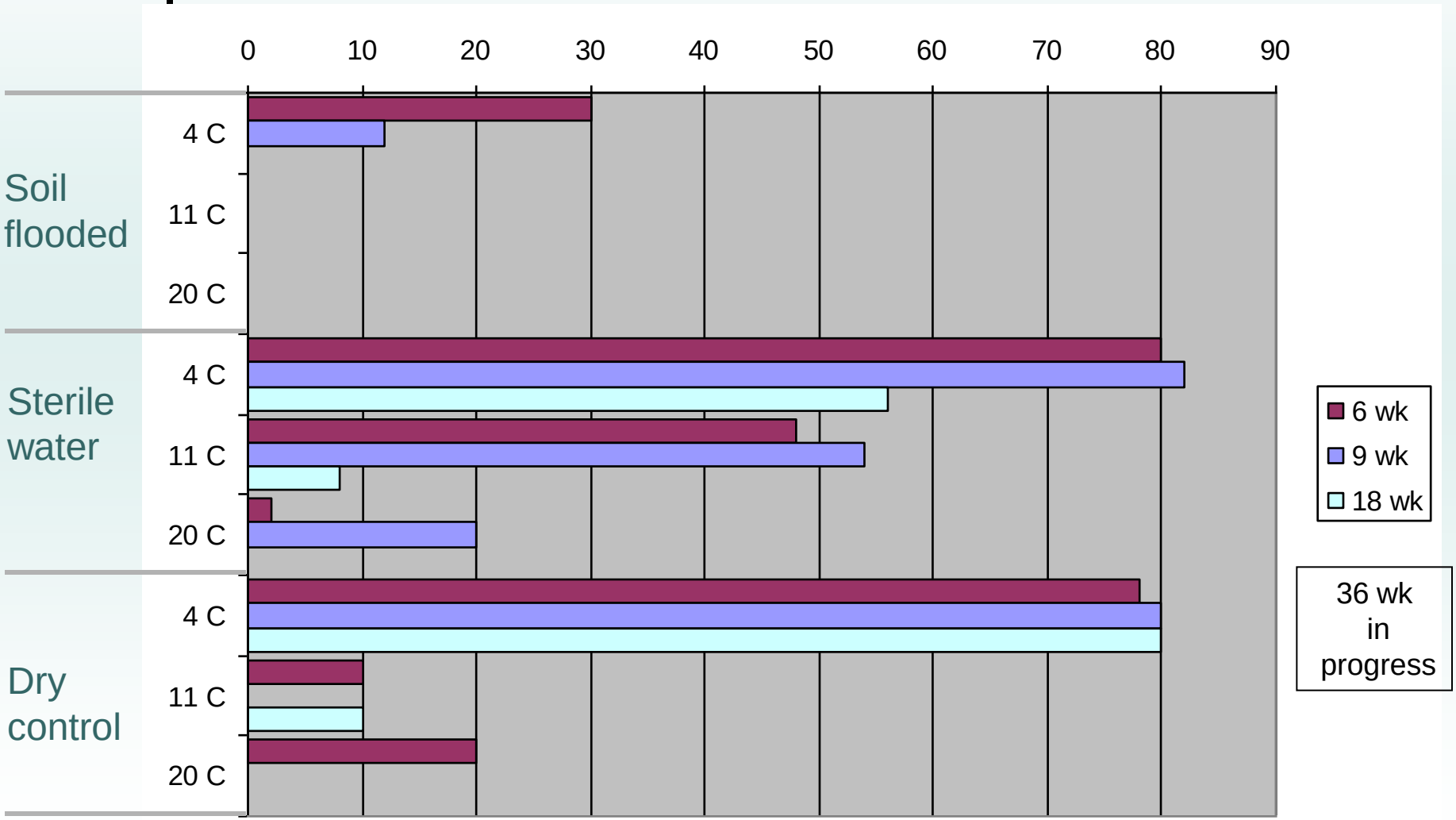
*Sclerotinia g*rowth chamber temperature tests



% Germination of *Sclerotinia* sclerotia
Growth chamber temperature test 10-1



% Germination of *Sclerotinia* sclerotia
Growth chamber temperature test 10-2

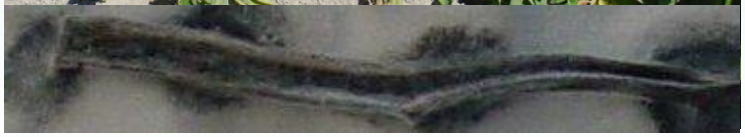




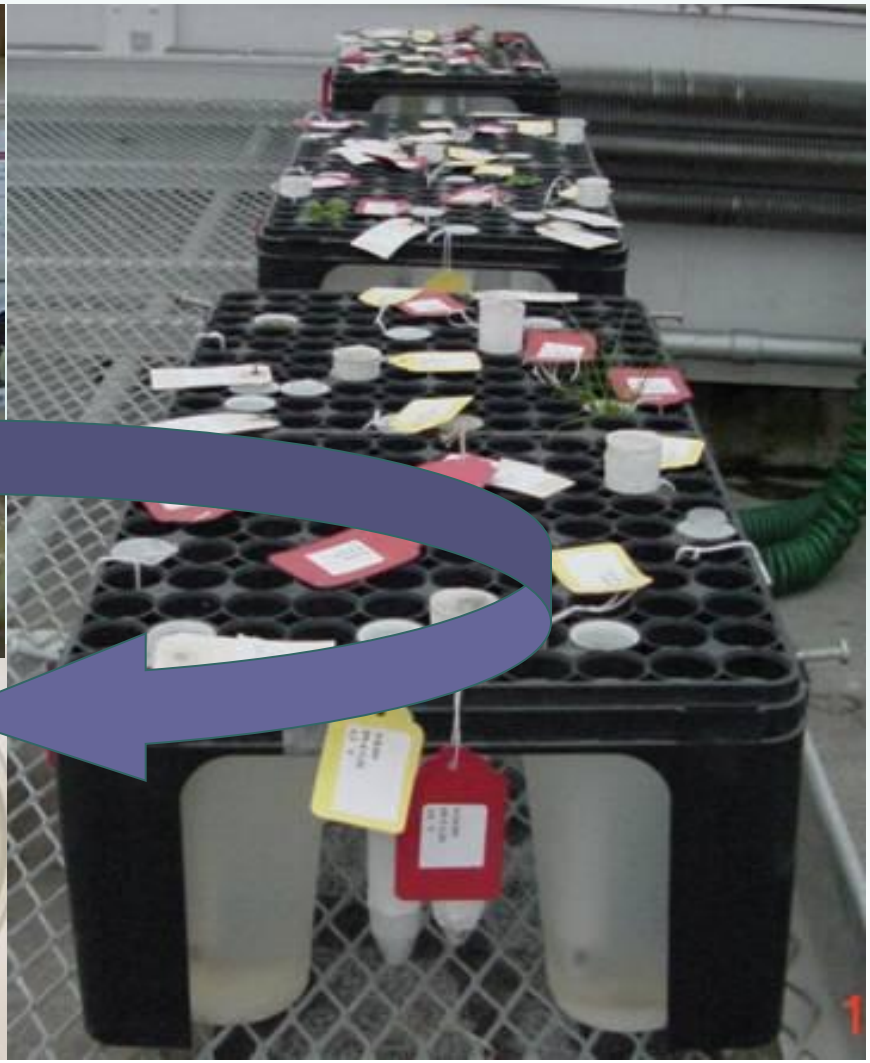
Greenhouse pathogenicity tests on potato with the *Sclerotinia* isolates recovered at different times

Sclerotinia white mold
is a good candidate

Verticillium wilt
?

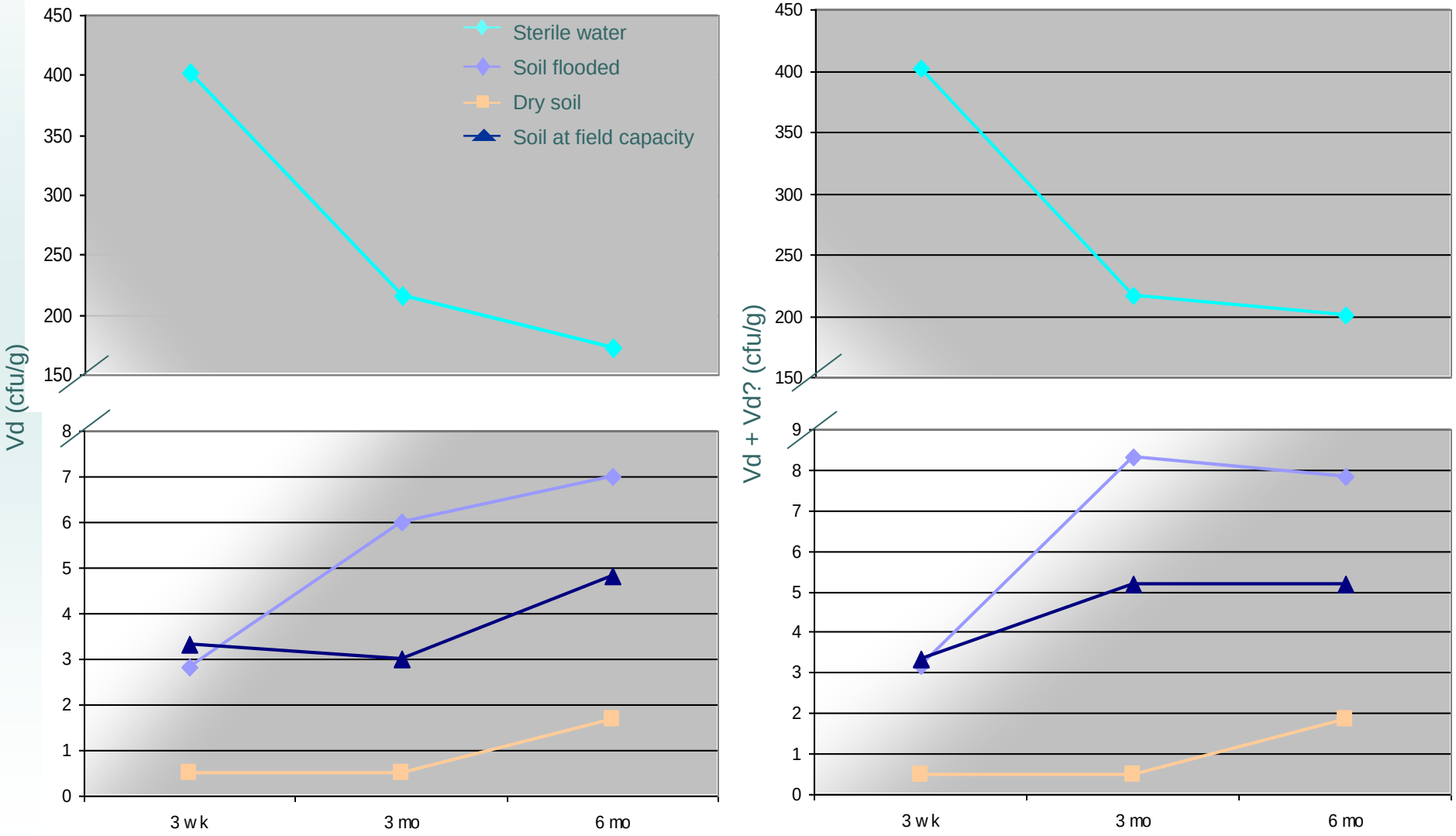


Verticillium greenhouse tests in cone-tainers



6 reps/treatment
90 cfu/g cone soil
0.1 g soil/plate
NP-10 media

Verticillium recovered (cfu/g soil) in greenhouse test 09-2



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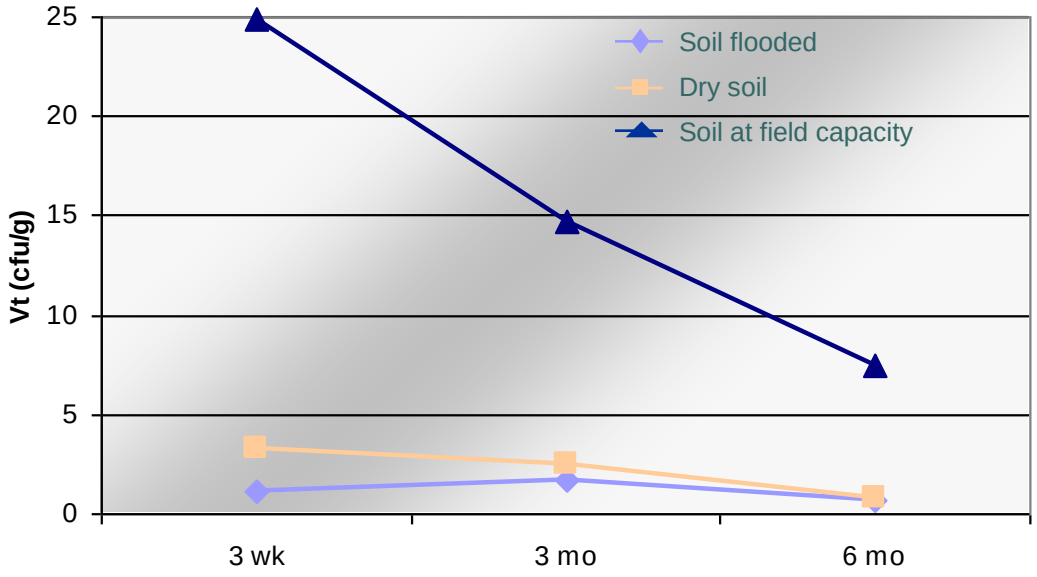
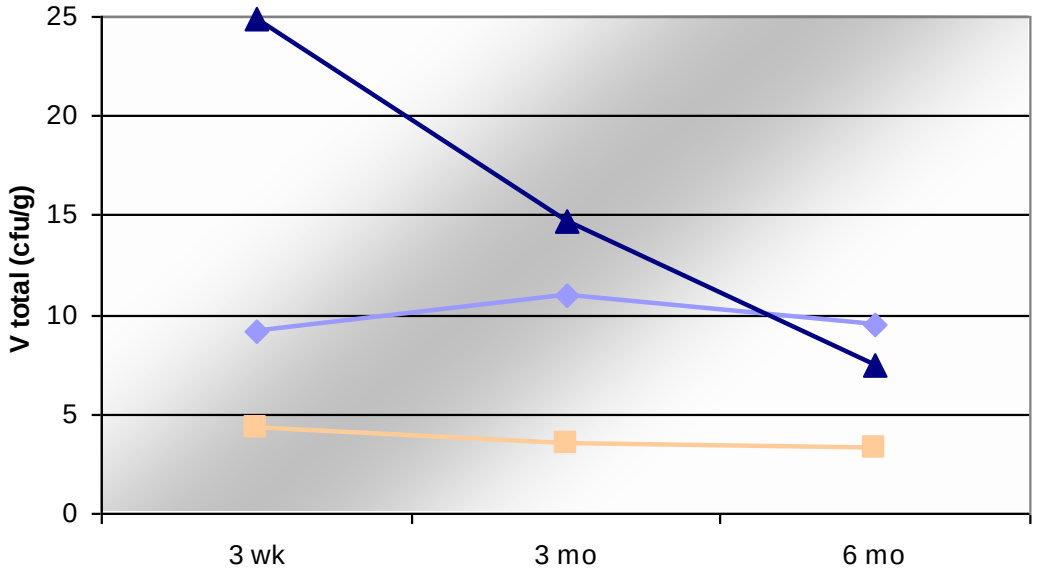
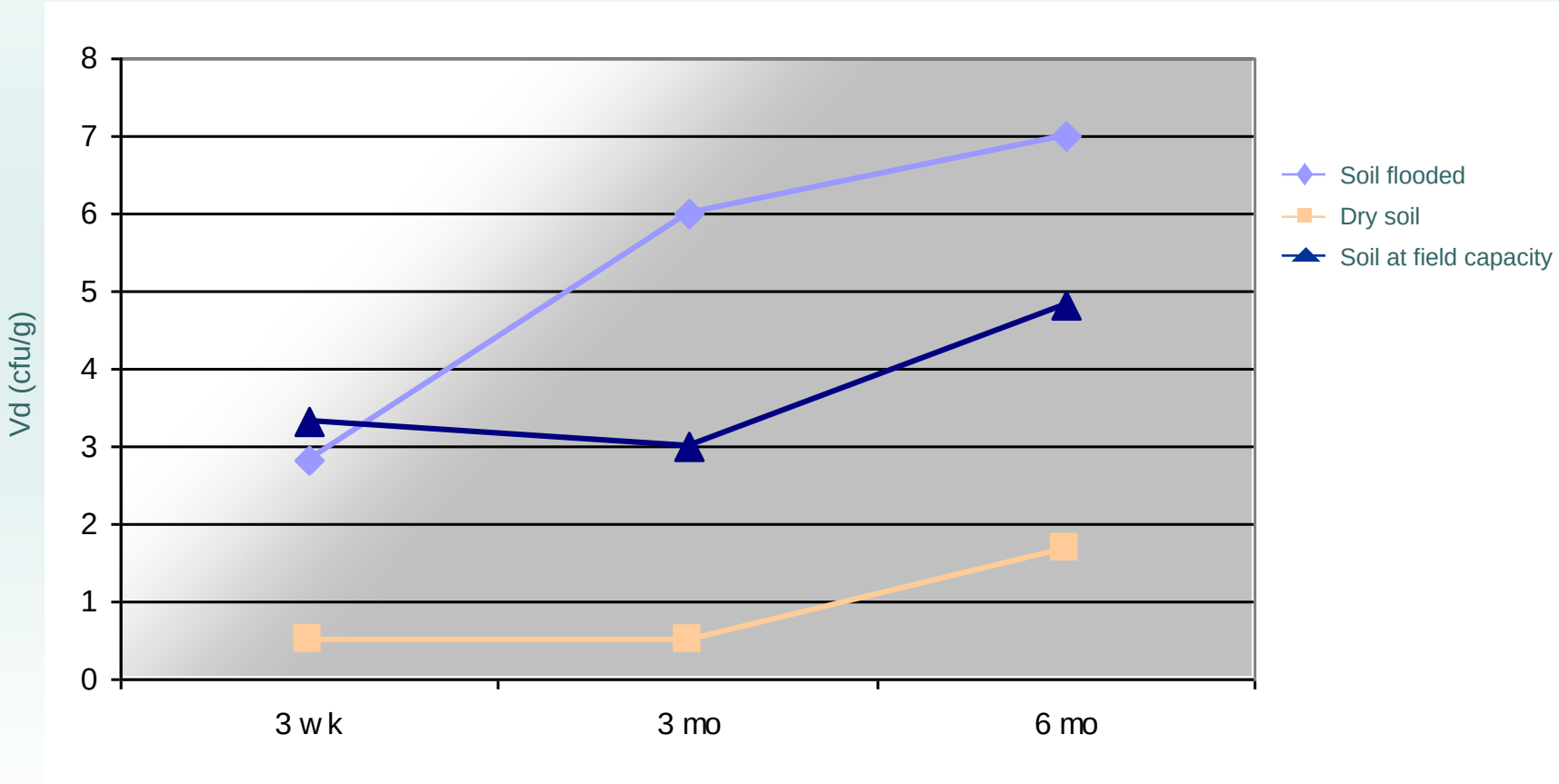
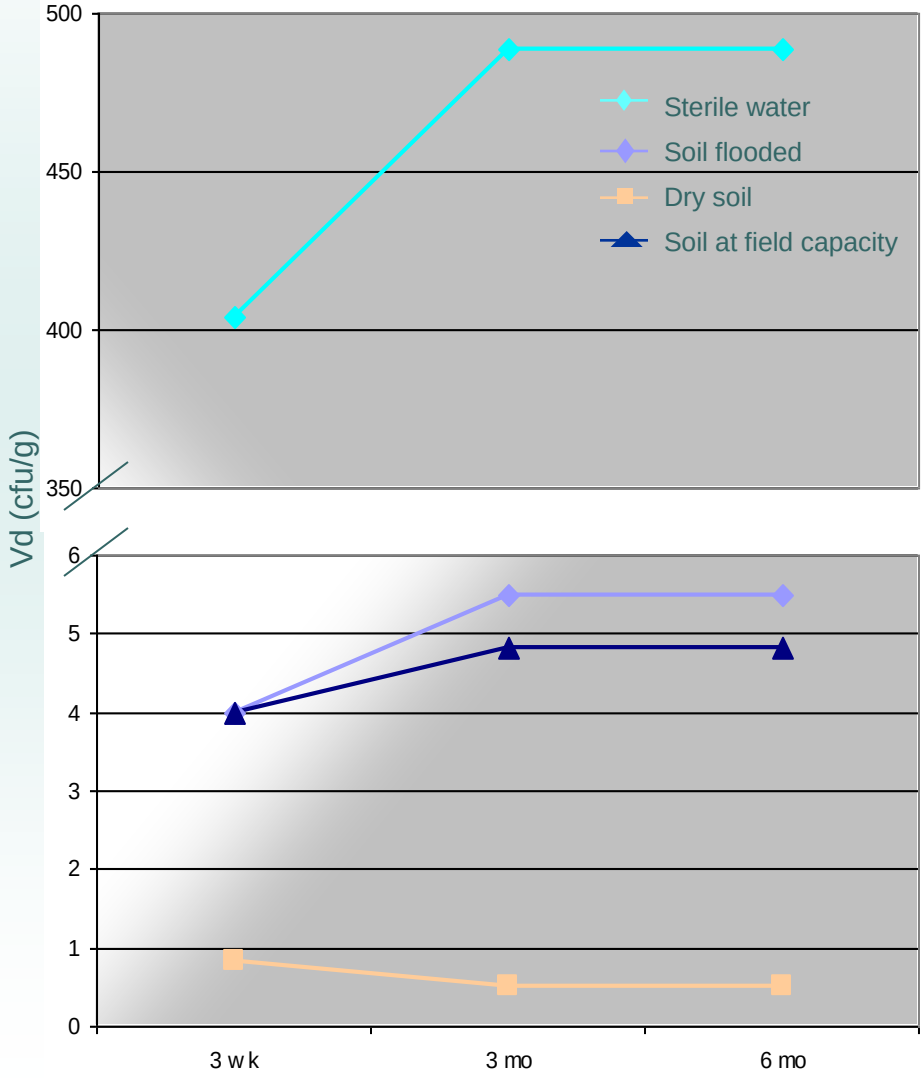


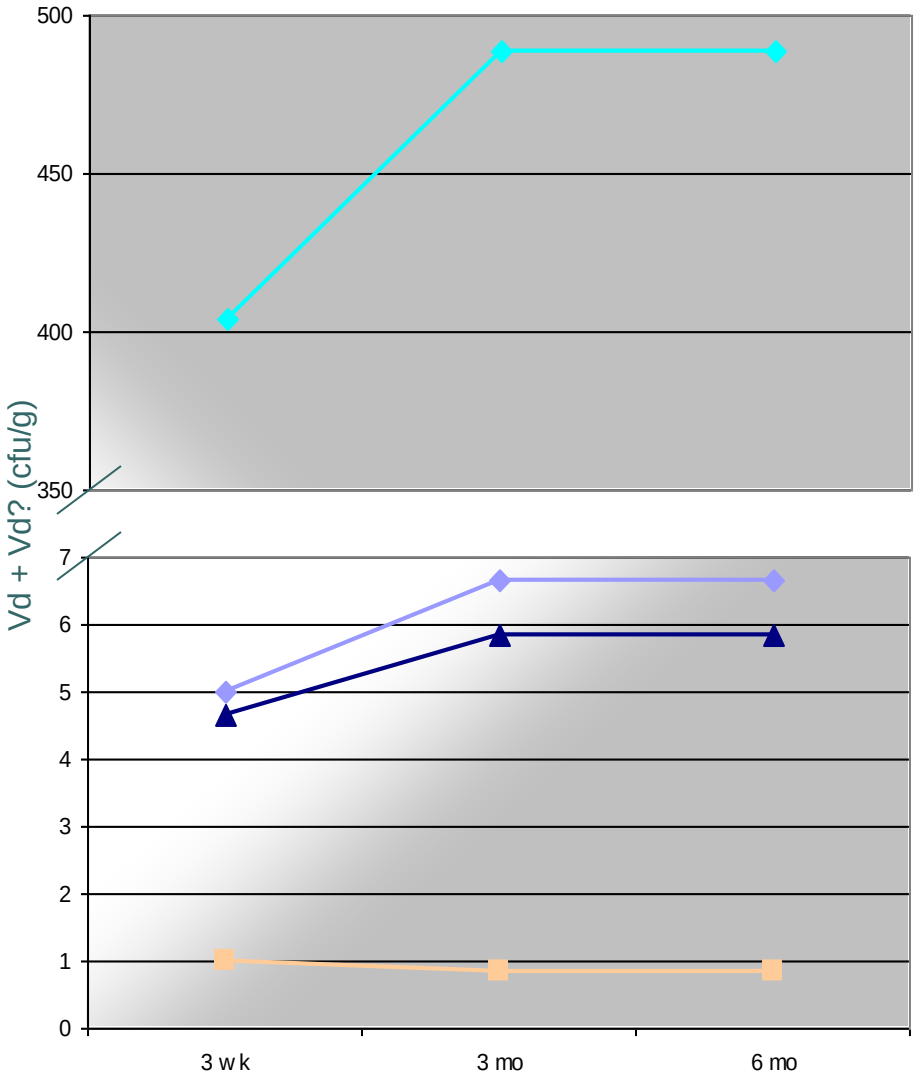


V. dahliae recovered (cfu/g soil) in greenhouse test 09-2

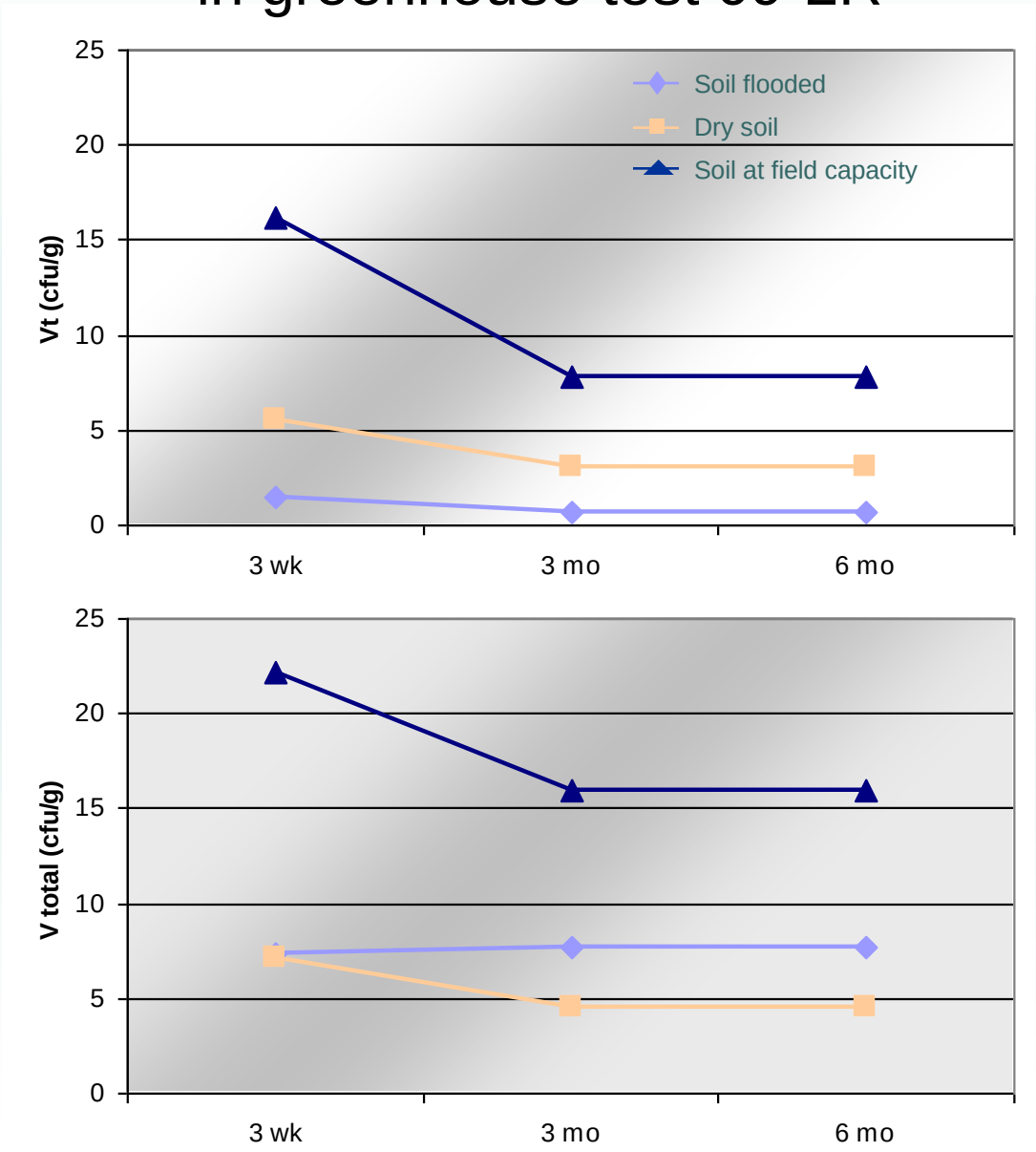


Verticillium recovered (cfu/g soil) in greenhouse test 09-2R

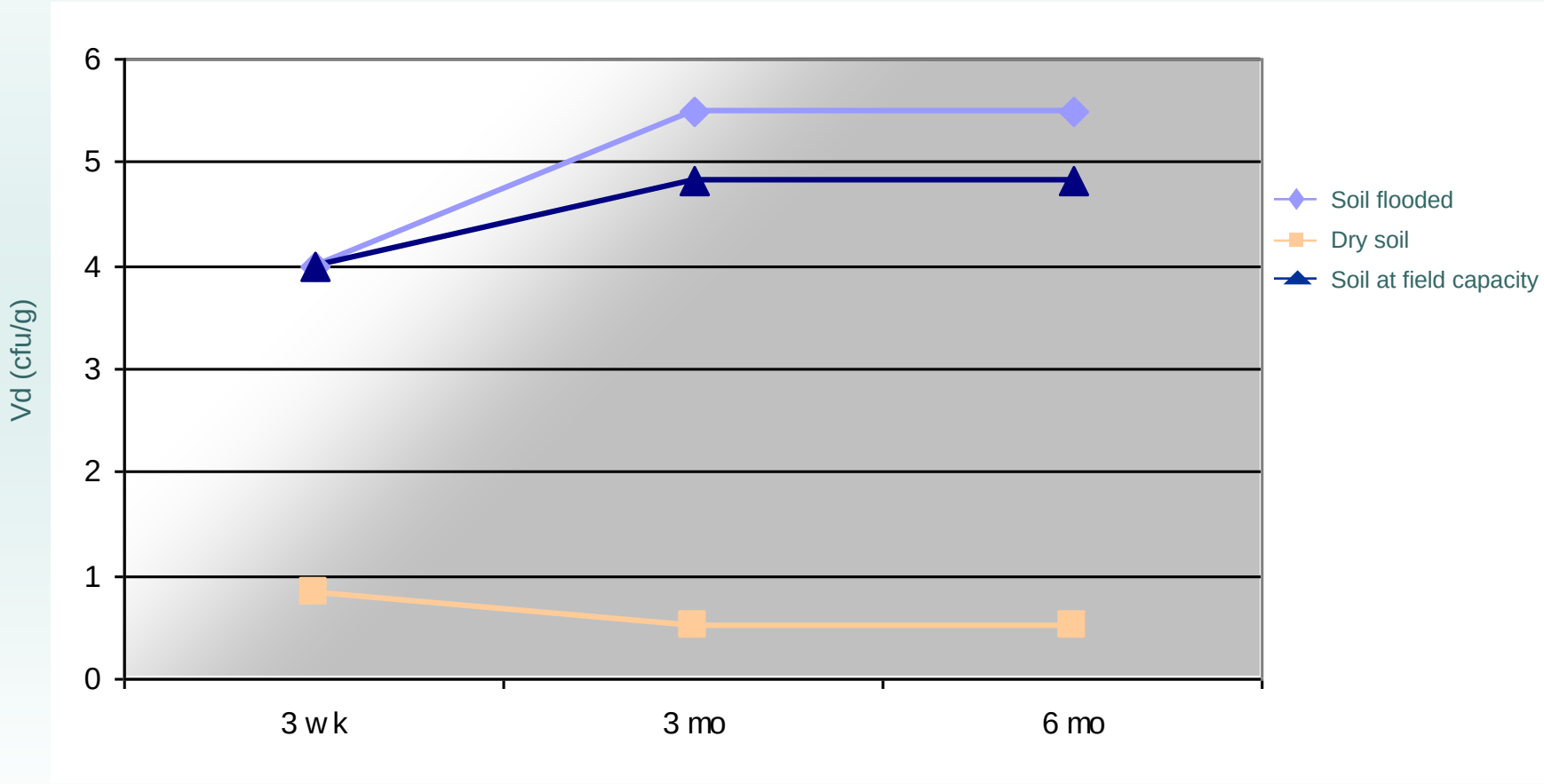




Verticillium recovered (cfu/g soil) in greenhouse test 09-2R



V. dahliae recovered (cfu/g soil) in greenhouse test 09-2R



Verticillium pathogenicity test on potato with recovered isolate, Vd03-53

Verticillium recovery from potato stems after 3 wk:

-- 100 % if in dry soil

-- 93 % if in soil at field capacity

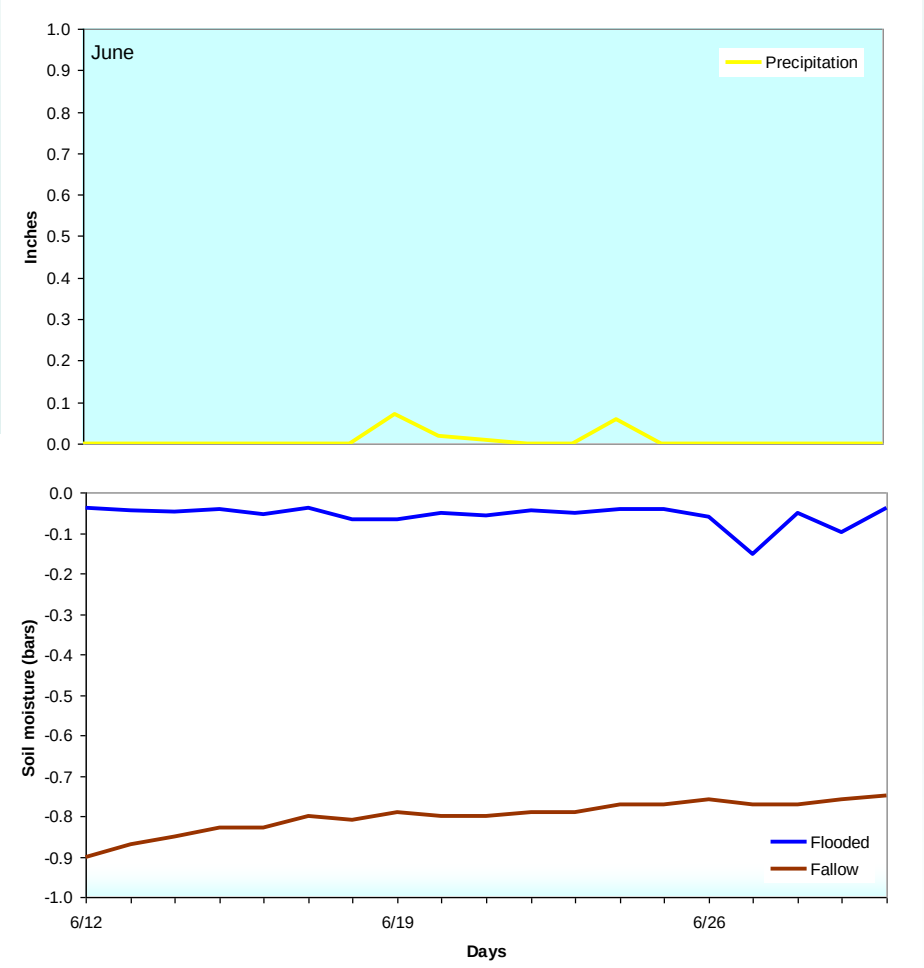
-- 40 % if in flooded soil

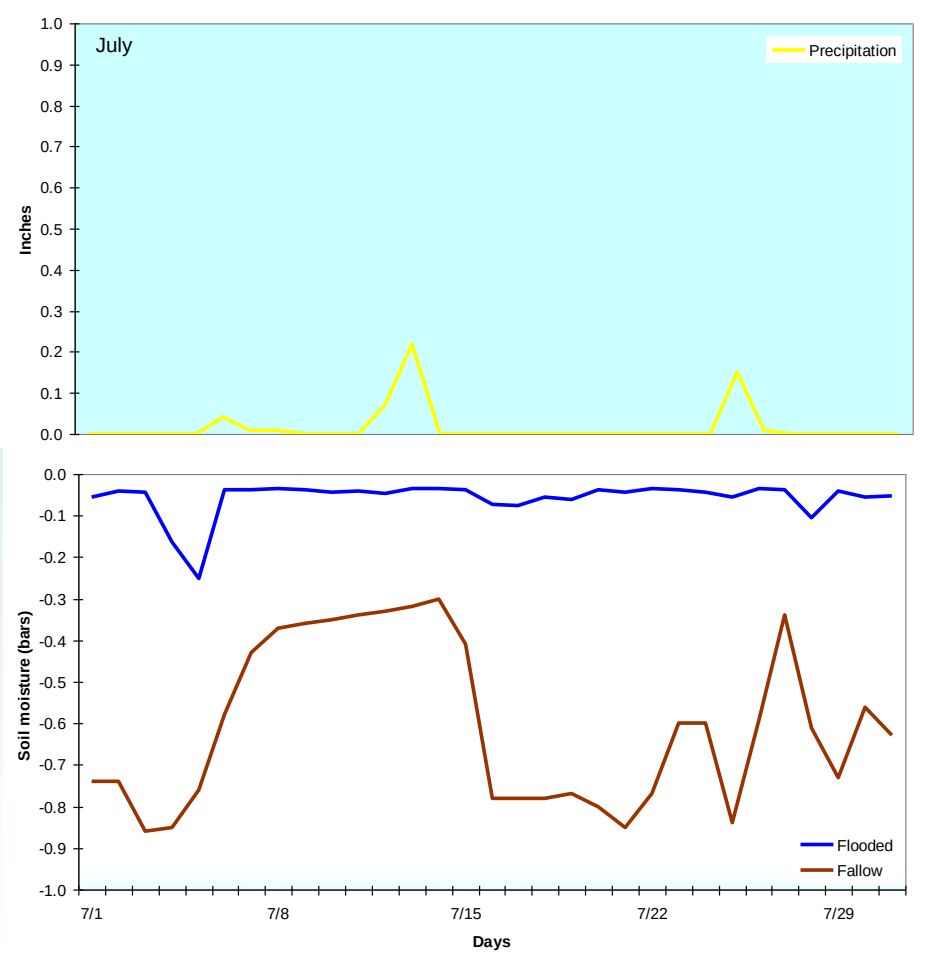
-- 50 % if in sterile water

The 3 and 6 mo recovery is in progress...

NWREC micro-plots flooded or fallowed in 2009, and cropped to potatoes in 2010

Precipitation (top) and soil moisture (bottom) for flooded (blue) and fallowed (brown) microplots, 2009





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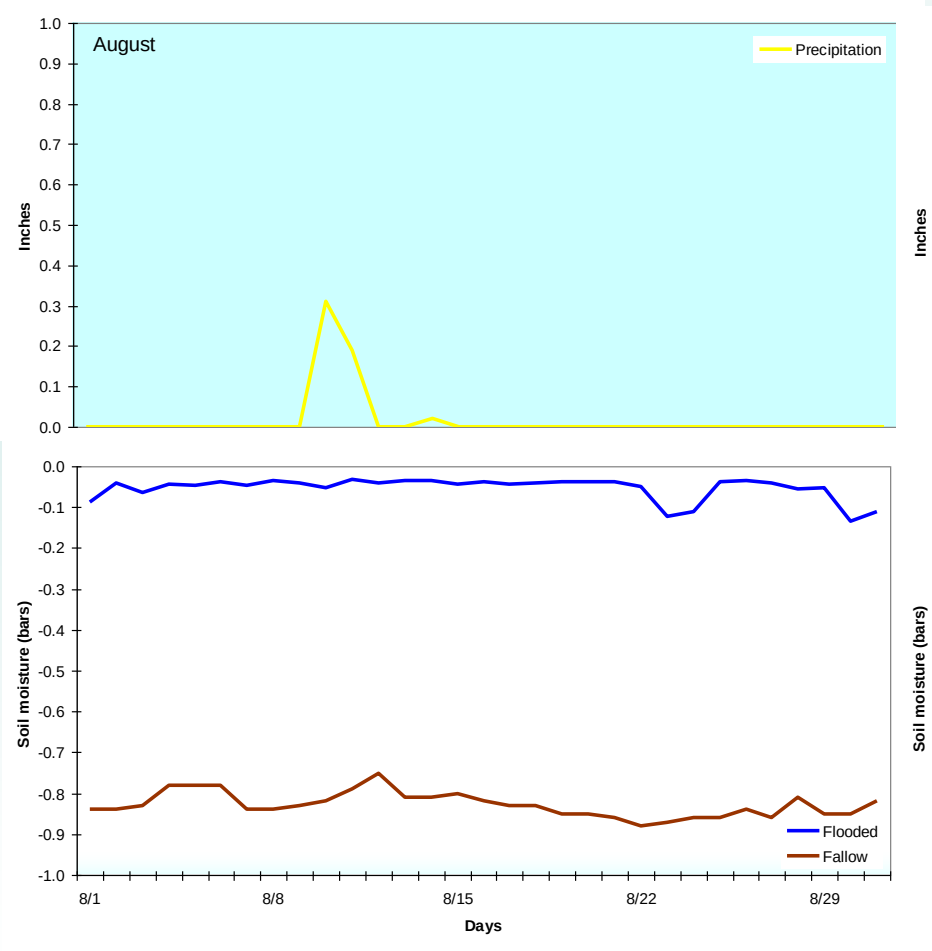

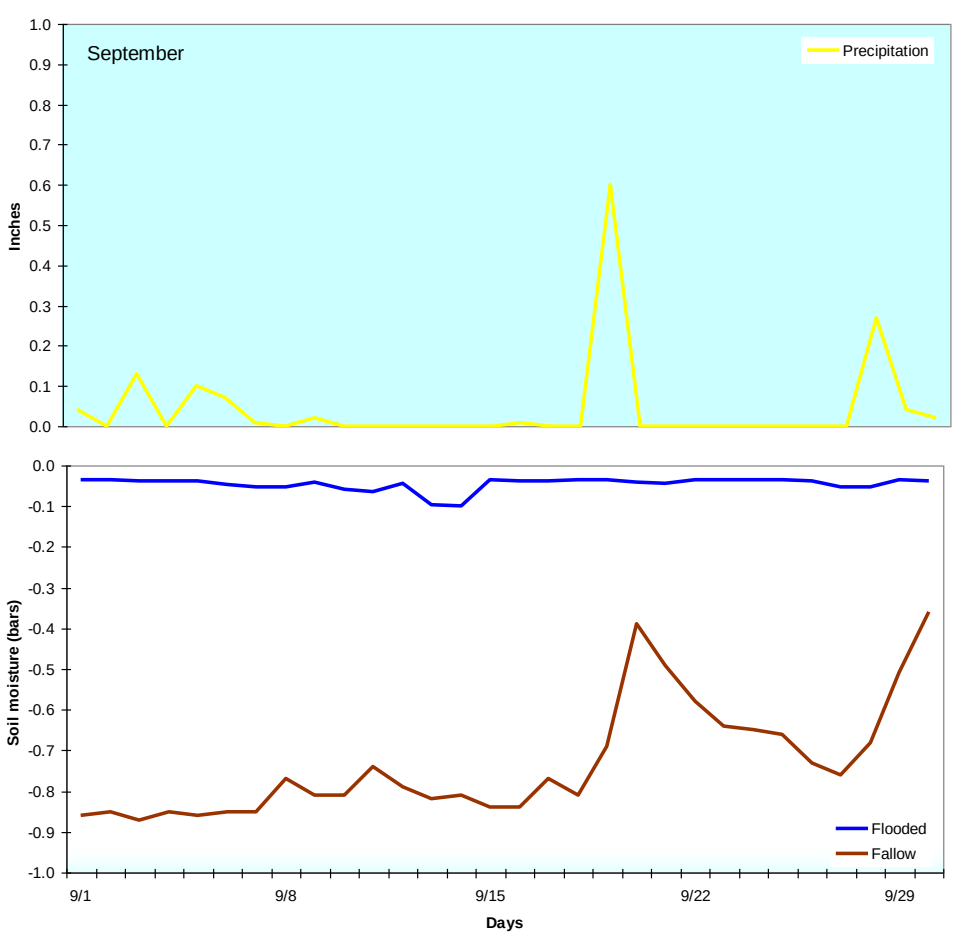

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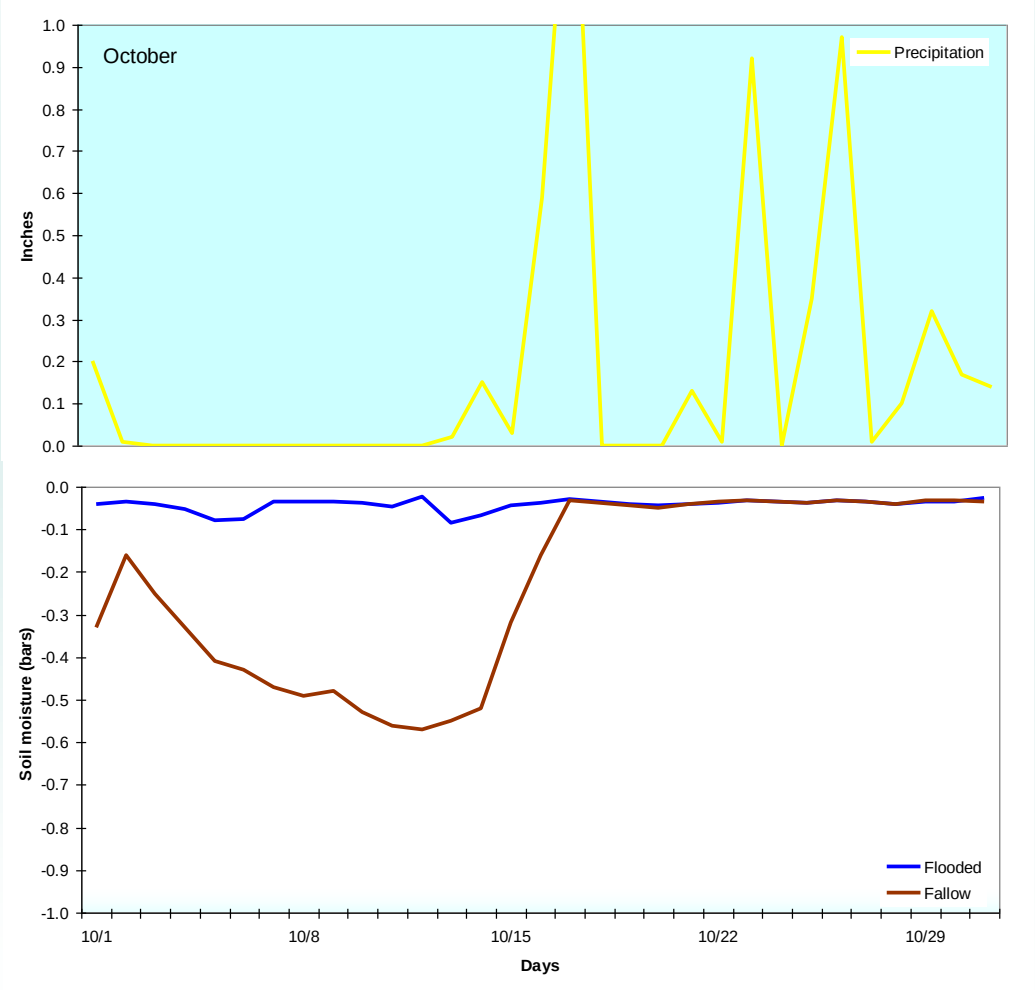
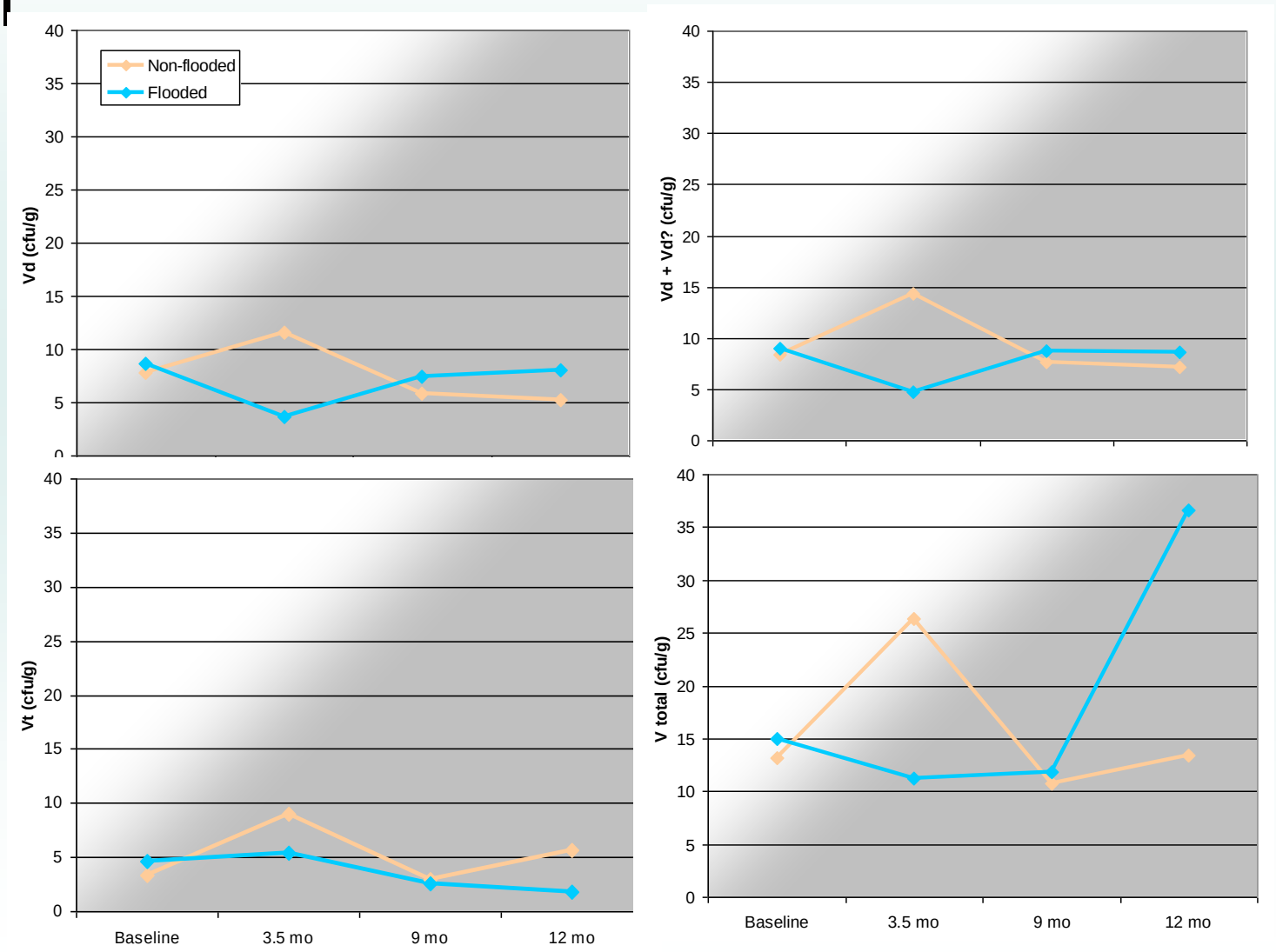
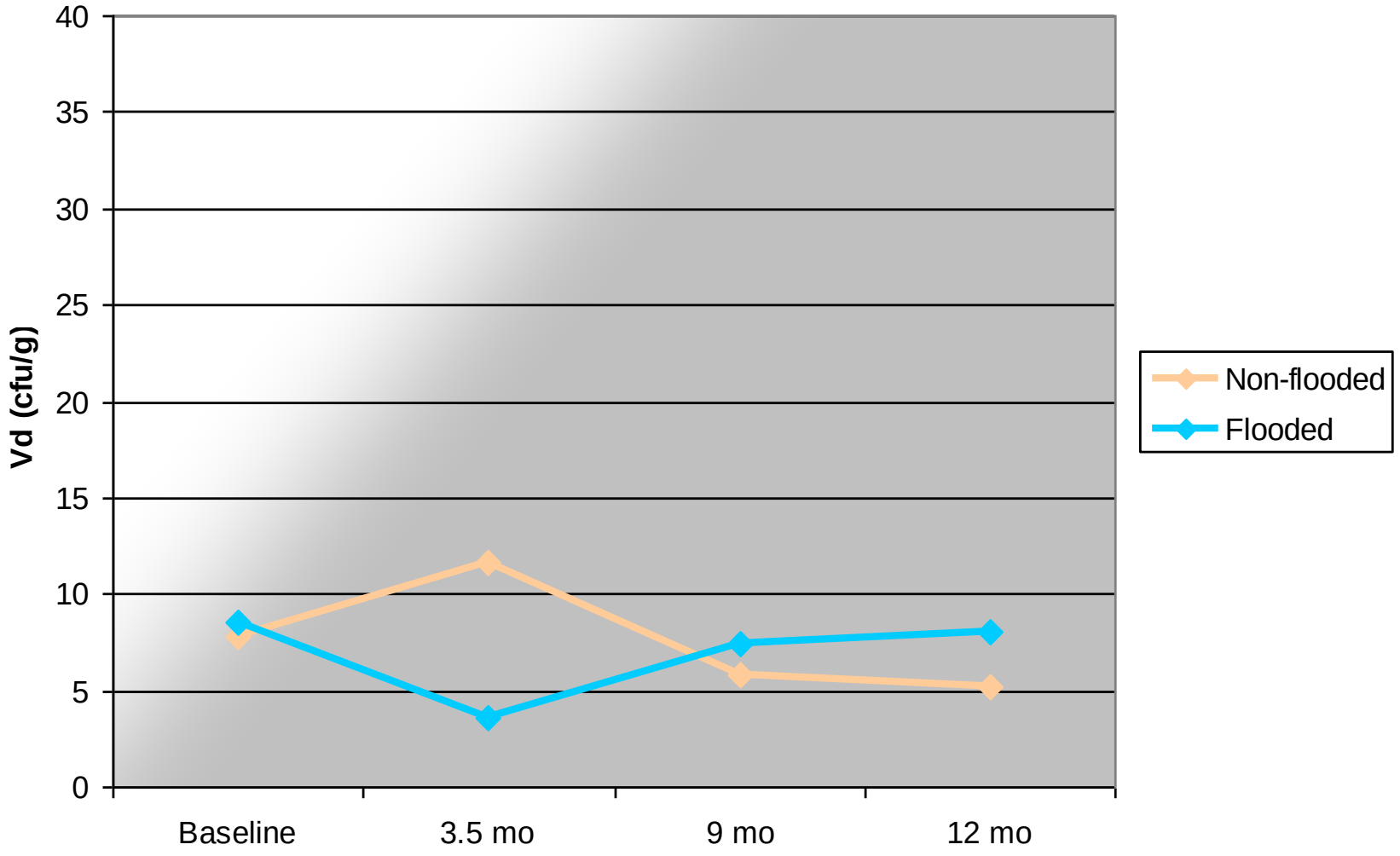


Verticillium recovered (cfu/g soil) in field microplots during 2009



V. dahliae recovered (cfu/g soil) in field microplots during 2009



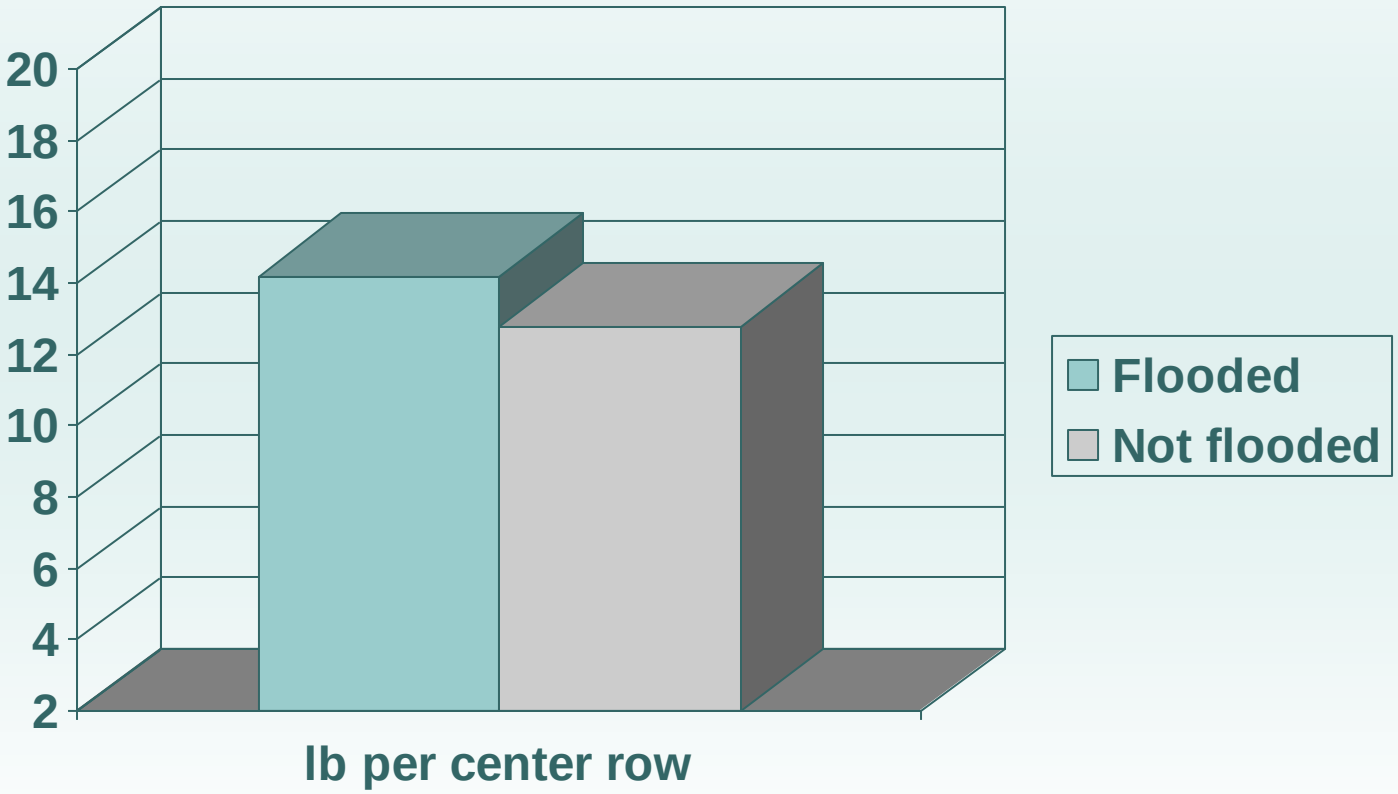
Microplot was fallowed in 2009; planted in 2010

100% recovery of *Verticilium* from sampled stems

Microplot was flooded in 2009; planted in 2010

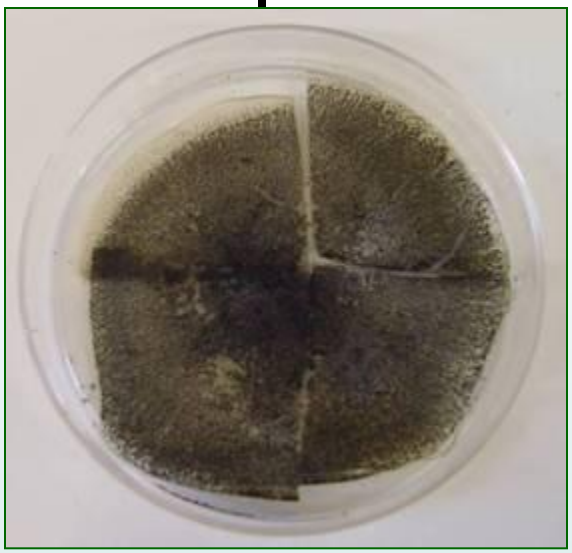
100% recovery of *Verticilium* from sampled stems

Yield of Russet Norkotah tubers in 2010

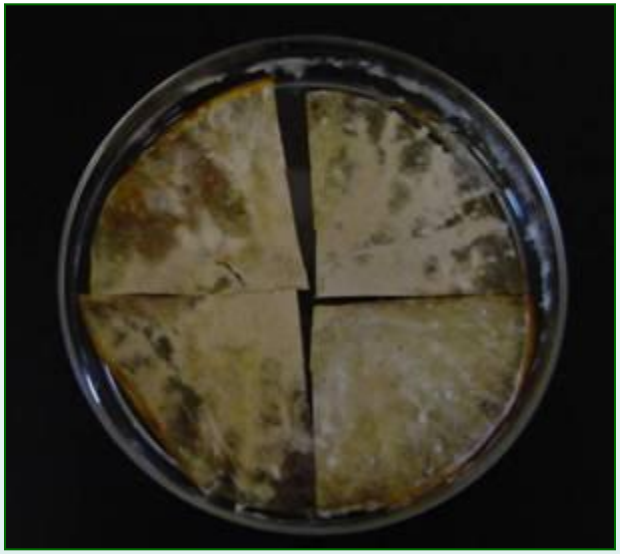


Micro-plot treatments replicated 5 times; each 3-row plot ~12 ft long

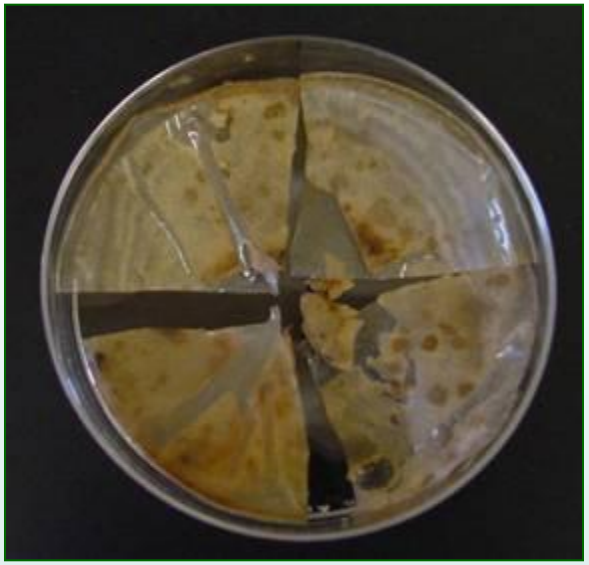
The ‘Shameful Six”



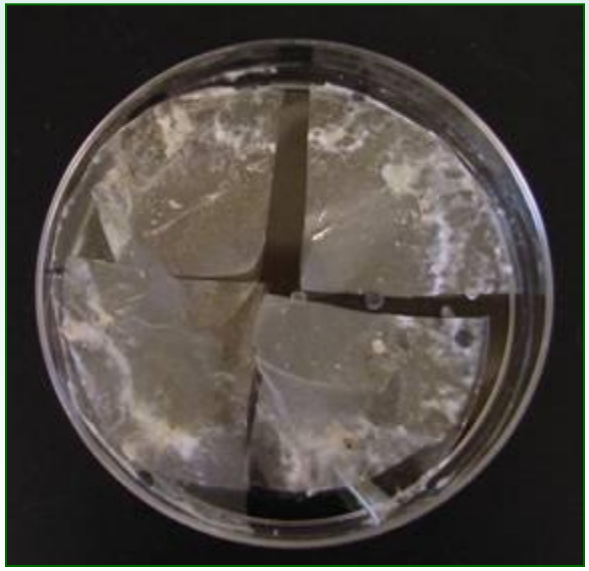
Colletotrichum



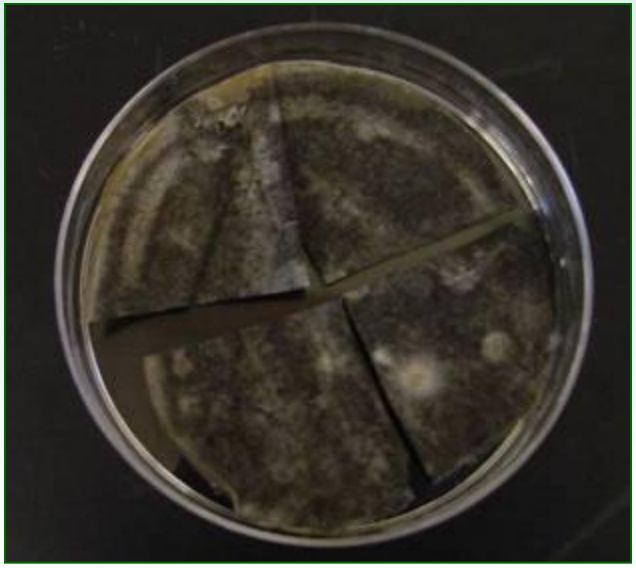
Fusarium



Rhizoctonia



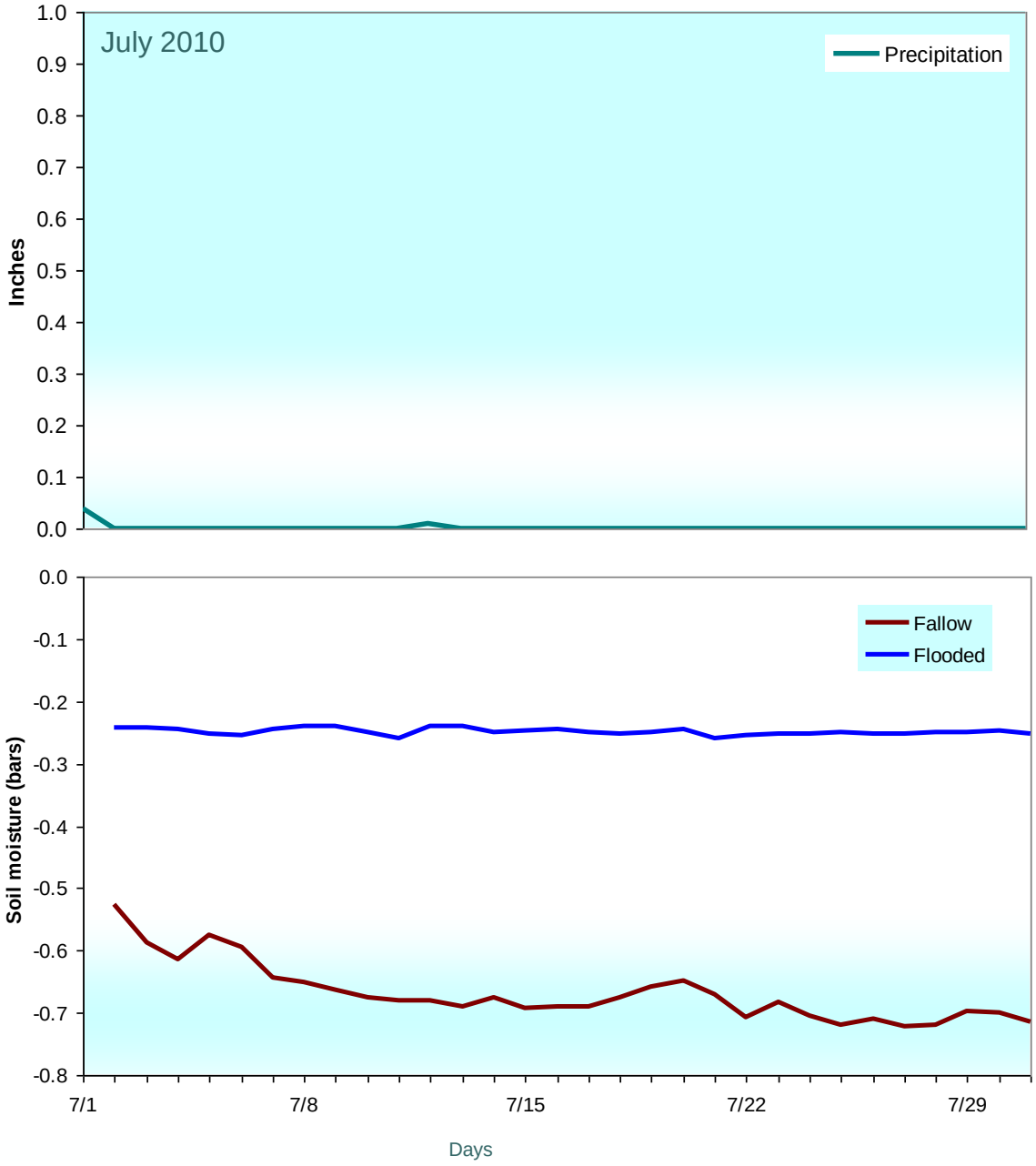
Sclerotinia

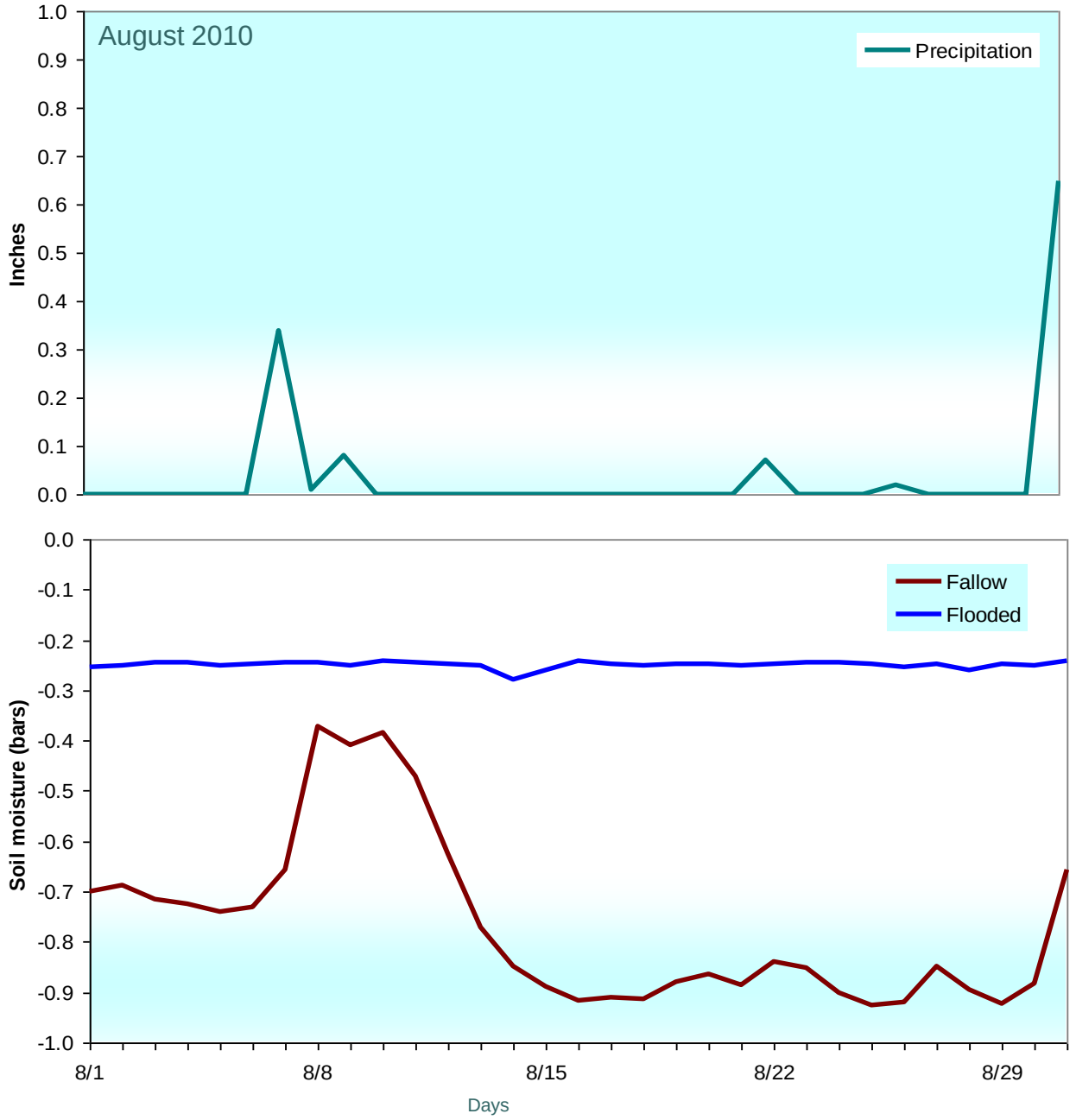


Helminthosporium

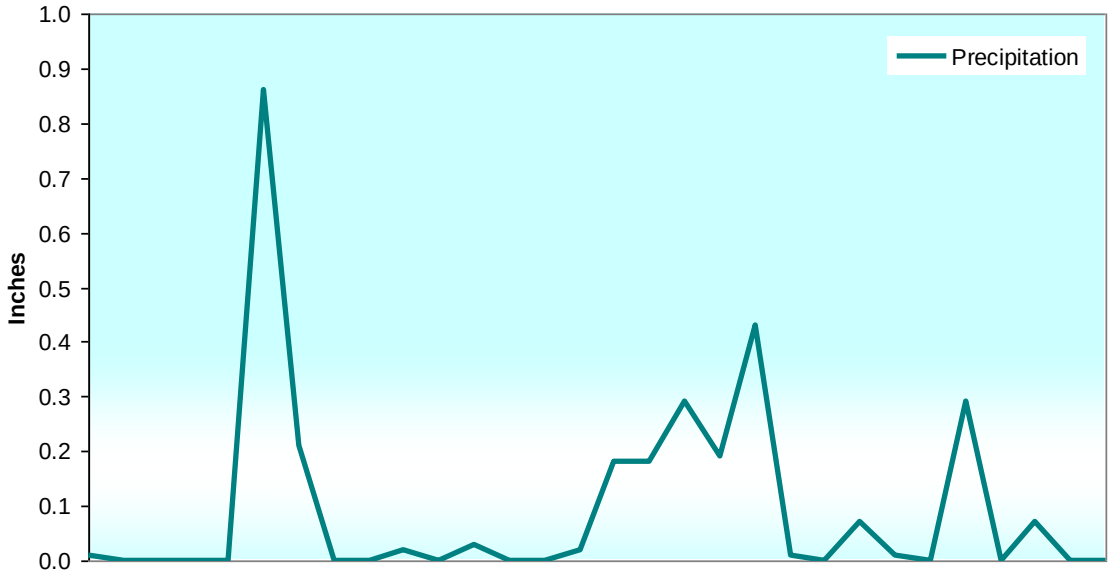
Verticillium

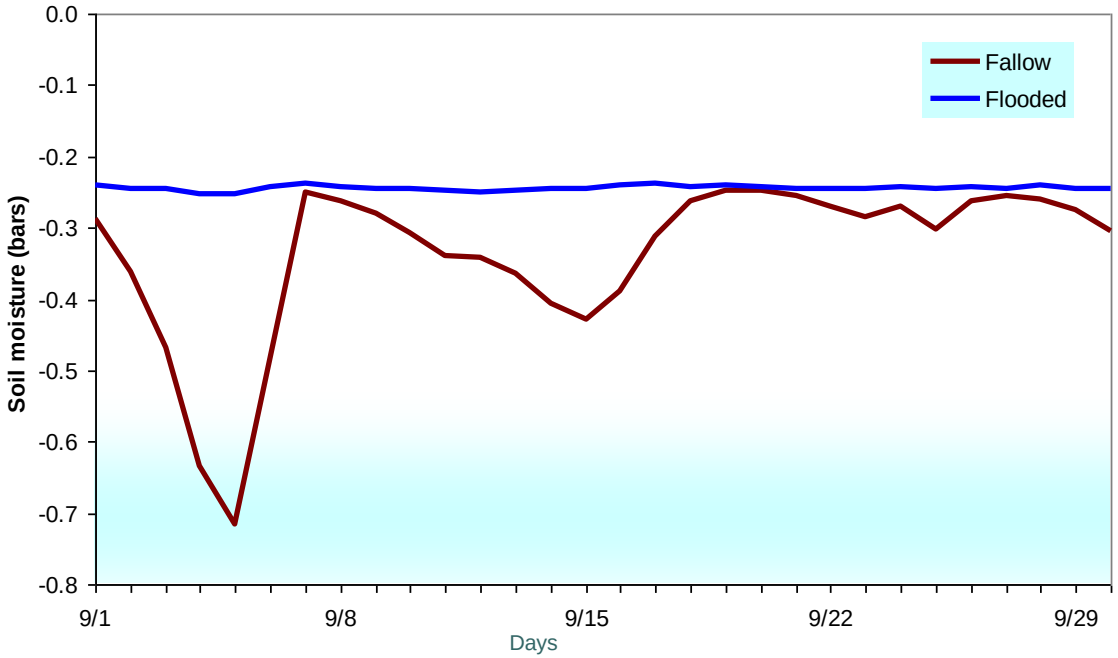
2010 ‘Shameful Six’ in flooded and fallow microplots


July 2010
Precipitation
Inches
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fallow
Flooded
Soil moisture (bars)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
7/1
7/8
7/15
7/22
7/29
Days

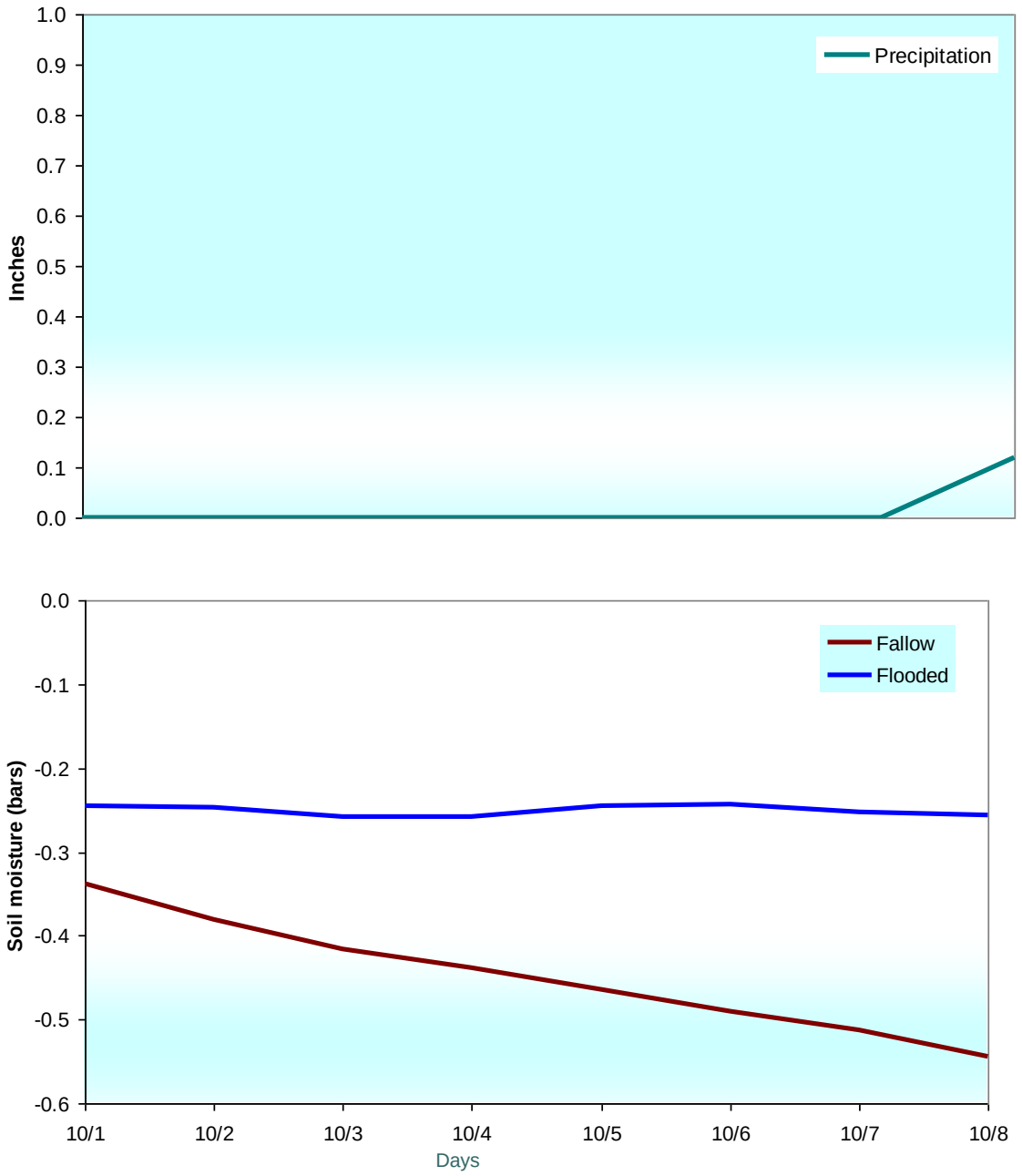

August 2010
Precipitation
Inches
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Fallow
Flooded
Soil moisture (bars)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
8/1
8/8
8/15
8/22
8/29
Days

September 2010





October 2010



3 week

So far...

Not flooded:

+ *Colletotrichum*
x *Fusarium*
? *Helminthosporium*
+ *Rhizoctonia*
- *Sclerotinia*
+ *Verticillium*

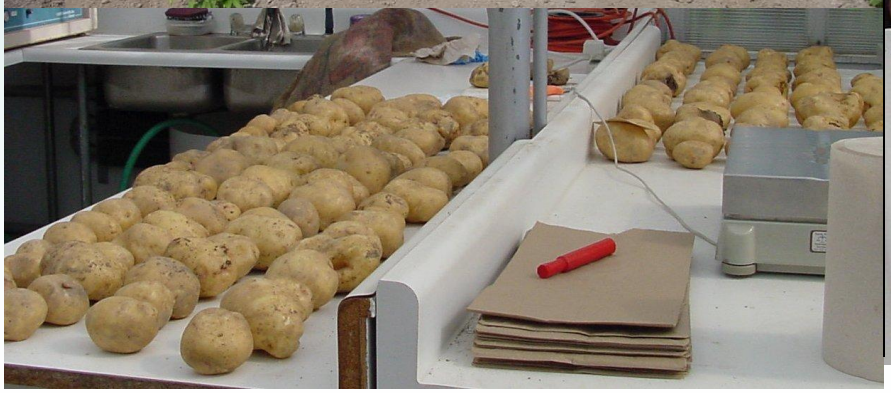
Flooded:

+ *Colletotrichum*
x *Fusarium*
- *Helminthosporium*
? *Rhizoctonia*
- *Sclerotinia*
+ *Verticillium*

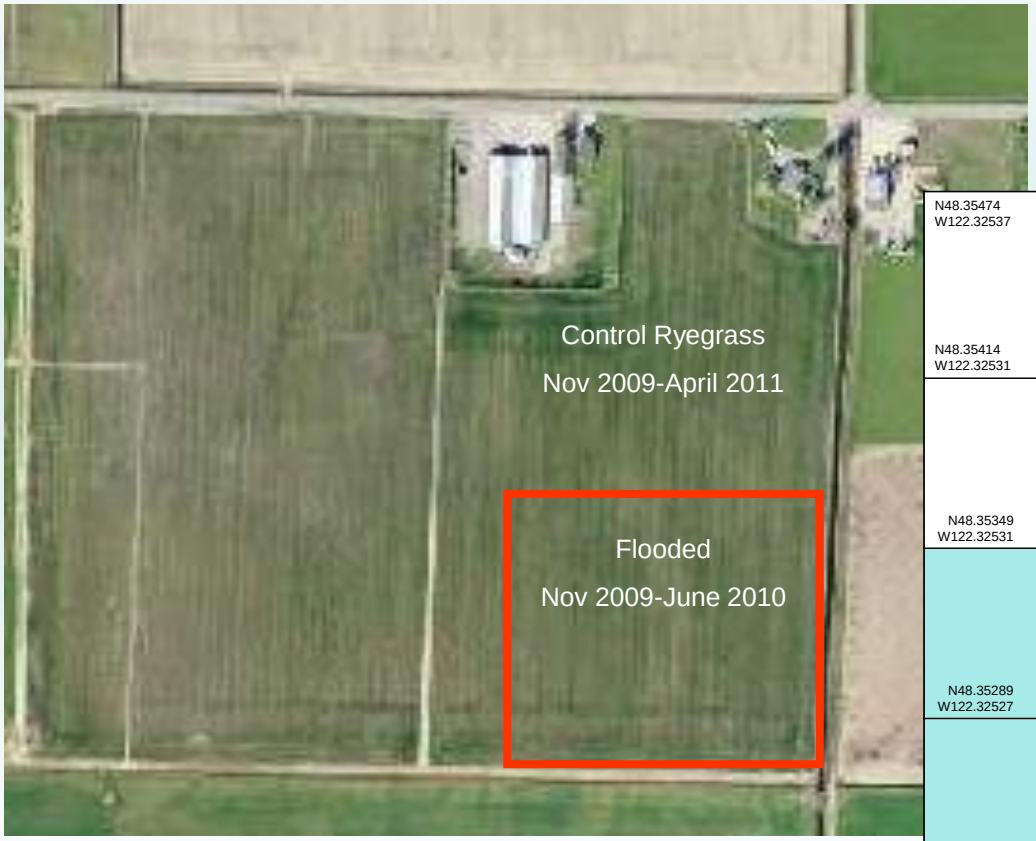
2009 TNC sites: *No serious fungal diseases*

Morrison

Waltner



Morrison on-farm site, 2010



N

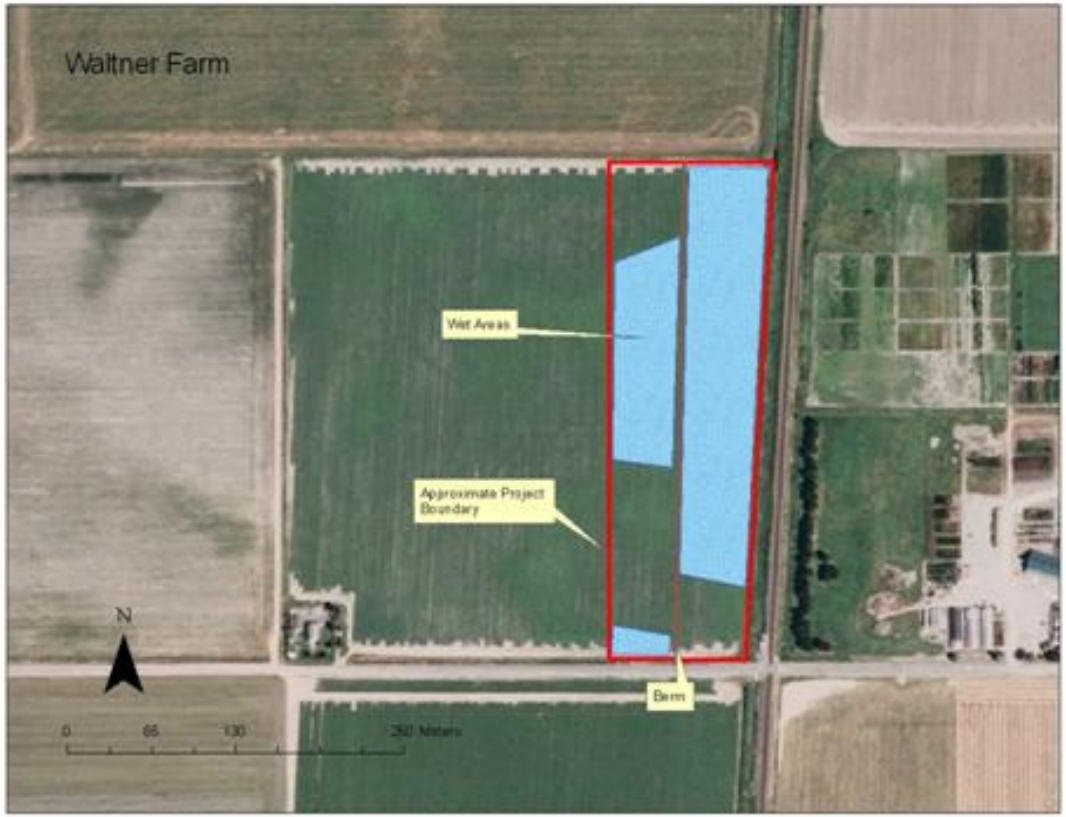
TNC On-Farm Field Study: Morrison Site

N48.35474 W122.32537	N48.35474 W122.32493	N48.35472 W122.32458	N48.35474 W122.32416	N48.35475 W122.32368
Mrsn-16	Mrsn-15	Mrsn-14	Mrsn-13	
N48.35414 W122.32531	N48.35412 W122.32490	N48.35406 W122.32459	N48.35411 W122.32413	N48.35413 W122.32367
Mrsn-12	Mrsn-11	Mrsn-10	Mrsn-9	
N48.35349 W122.32531	N48.35345 W122.32516	N48.35352 W122.32452	N48.35355 W122.32418	N48.35351 W122.32373
Mrsn-8	Mrsn-7	Mrsn-6	Mrsn-5	
N48.35289 W122.32527	N48.35288 W122.32497	N48.35285 W122.32452	N48.35293 W122.32420	N48.35302 W122.32374
Mrsn-4	Mrsn-3	Mrsn-2	Mrsn-I	
N48.35232 W122.32527	N48.35240 W122.32513	N48.35231 W122.32452	N48.35233 W122.32419	N48.35242 W122.32384

Irrigation ditch

Irrigation ditch

Waltner on-farm site, 2010



TNC On-Farm Field Study: Waltner Site

N

N48.35948 W122.34238	N48.35944 W122.34174	N48.35946 W122.34097
Wltn-16		Wltn-15
N48.35920 W122.34241	N48.35918 W122.34175	N48.35919 W122.34101
Wltn-14		Wltn-13
N48.35876 W122.34251	N48.35875 W122.34179	N48.35873 W122.34106
Wltn-12		Wltn-11
N48.35827 W122.34252	N48.35826 W122.34177	N48.35825 W122.34110
Wltn-10		Wltn-9
N48.35779 W122.34254	N48.35780 W122.34184	N48.35783 W122.34114
Wltn-8		Wltn-7
N48.35732 W122.34262	N48.35735 W122.34188	N48.35735 W122.34118
Wltn-6		Wltn-5
N48.35689 W122.34264	N48.35689 W122.34195	N48.35688 W122.34124
Wltn-4		Wltn-3
N48.35645 W122.34269	N48.35640 W122.34195	N48.35643 W122.34128
Wltn-2		Wltn-1
N48.35600 W122.34273	N48.35598 W122.34203	N48.35596 W122.34132

Irrigation ditch

Railroad tracks

Johnson Road

Soil samples[1]	Morrison field site Estimated baseline soil populations (CFU/g soil)[2]		
	Pythium/Phytophthora[3]	***Fusarium***[3]	***Verticillium***[4]
Assigned Fallow			
Q-9 + Q-10	10,667	13,556	0
Q-11 + Q-12	8,667	6,889	0
Q-13 + Q-14	8,889	18,667	4
Q-15 + Q-16	6,222	8,667	4
Average	**8,611**	**11,944**	**2**
Assigned Flooded			
Q-1 + Q-2	7,556	18,444	0
Q-3 + Q-4	10,444	9,556	0
Q-5 + Q-6	7,778	13,333	6
Q-7 + Q-8	8,222	8,889	6
Average	**8,500**	**12,556**	**3**

Soil samples[1]	Waltner field site Estimated baseline soil populations (CFU/g soil)[2]		
	Pythium/Phytophthora[3]	***Fusarium***[3]	***Verticillium***[4]
Assigned Fallow			
Q-2 + Q-4	6,889	16,000	0
Q-6 + Q-8	6,667	20,444	0
Q-10 + Q-12	7,333	18,444	0
Q-14 + Q-16	8,444	13,333	2
Average	**7,386**	**17,216**	**0.5**
Assigned Flooded			
Q-1 + Q-3	9,778	15,333	0
Q-5 + Q-7	7,111	23,333	0
Q-9+ Q-11	5,778	14,889	0
Q-13 + Q-15	8,667	16,667	0
Average	**7,689**	**18,237**	**0**

Project Accomplishments in 2010

1. Two greenhouse and two growth chamber temperature experiments on survival of *Sclerotinia* sclerotia under flooded and non-flooded soil conditions, completed.
2. Two greenhouse experiments on survival of *Verticillium dahliae* microsclerotia under flooded and non-flooded soil conditions, completed.
3. One field microplot experiment (using *Verticillium* plots either flooded or not flooded in 2009, and replanted to potato Russet Norkotah in 2010): *V. dahliae* soil density and Verticillium wilt progress and potato yield, assessed.
4. One greenhouse assay on survival of *Verticillium* microsclerotia, in naturally-infected potato stems, nearly completed.

Project Accomplishments in Year 2

5. Pathogenicity of recovered fungal isolates on greenhouse potatoes, confirmed.

6. One preliminary field microplot experiment on survival of six selected soilborne potato pathogens (*Colletotrichum, Fusarium, Helminthosporium, Rhizoctonia, Sclerotinia, Verticillium*) under flooded and non-flooded conditions, initiated; needs refining.

7. Baseline data on *Fusarium, Pythium/Phytophthora*, and *Verticillium* soil counts and plant health and yield, obtained by quadrant, for on-farm sites in 2009.

Recommendations for utilizing plant pathology expertise efficiently:

- Focus on treatment comparisons for selected pathogens under controlled conditions ie., microplots and growth chamber experiments

- Minimize efforts at on-farm trials due to inconsistency in 2010 flooding treatments so as to not waste time and resources (pathogen, plant and tuber disease ratings only for selected quadrants where intended treatments were able to be maintained)

Thank you TNC, and Julie!