A review of the root rot diseases of common bean with emphasis in Latin America and Africa

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Skukuza, South Africa

Outline

- Context
- Diseases of Roots in LA and Africa
- Research in Latin America
- Research in Africa
- Lesson Learnt
- Future Perspective

Intensive agricultural production

Example of diseases & pests associated with intensification and aggravated by decline in soil fertility

- **Diseases / pests**
  - Bean root rots
  - Bean stem maggot
  - Nematodes
  - Banana weevil
  - Striga weed

Characteristics

- Soilborne
- Incidence / severity linked to intensification / decline in soil fertility
- Requires measures beyond single disciplinary approaches (commodity)
- Need IDPM and ISFM approaches for their management

Characteristic of areas associated with the diseases of intensification

- **Characteristics**
  - ✓ **High population density**
  - ✓ **Reduced land size**
  - ✓ **Intensification in land use (little or no rotation or fallow)**
  - ✓ **Declining soil fertility, nutrient depletion and land degradation**
  - ✓ **Little use of inorganic fertilizers or organic amendments**
  - ✓ **Inappropriate management practices that affect the soil habitat and environment**

- Effects
  - Imbalance between beneficial and harmful organisms
  - Increase in inoculum levels of soil borne pathogens and pests
  - Reduced plants tolerance
  - Frequent outbreak of pests and diseases
  - Shift or decline in host biodiversity
  - Yield and economic losses

Poor field conditions

Poor field conditions

Severely affected field

Severely affected field

Major diseases of bean in LA and Africa:

Pythium Root Rot	*Pythium* spp.
Fusarium Root Rot	*Fusarium solani* f.sp. *phaseoli*
Rhizoctonia Root Rot	*Rhizoctonia solani*
Fusarium Wilt	*Fusarium oxysporum* f.sp. *phaseoli*
Charcoal Rot	*Macrophomina phaseolina*
Southern Blight	*Sclerotium rolfsii*

Pythium Root Rot
(*Pythium* spp.)

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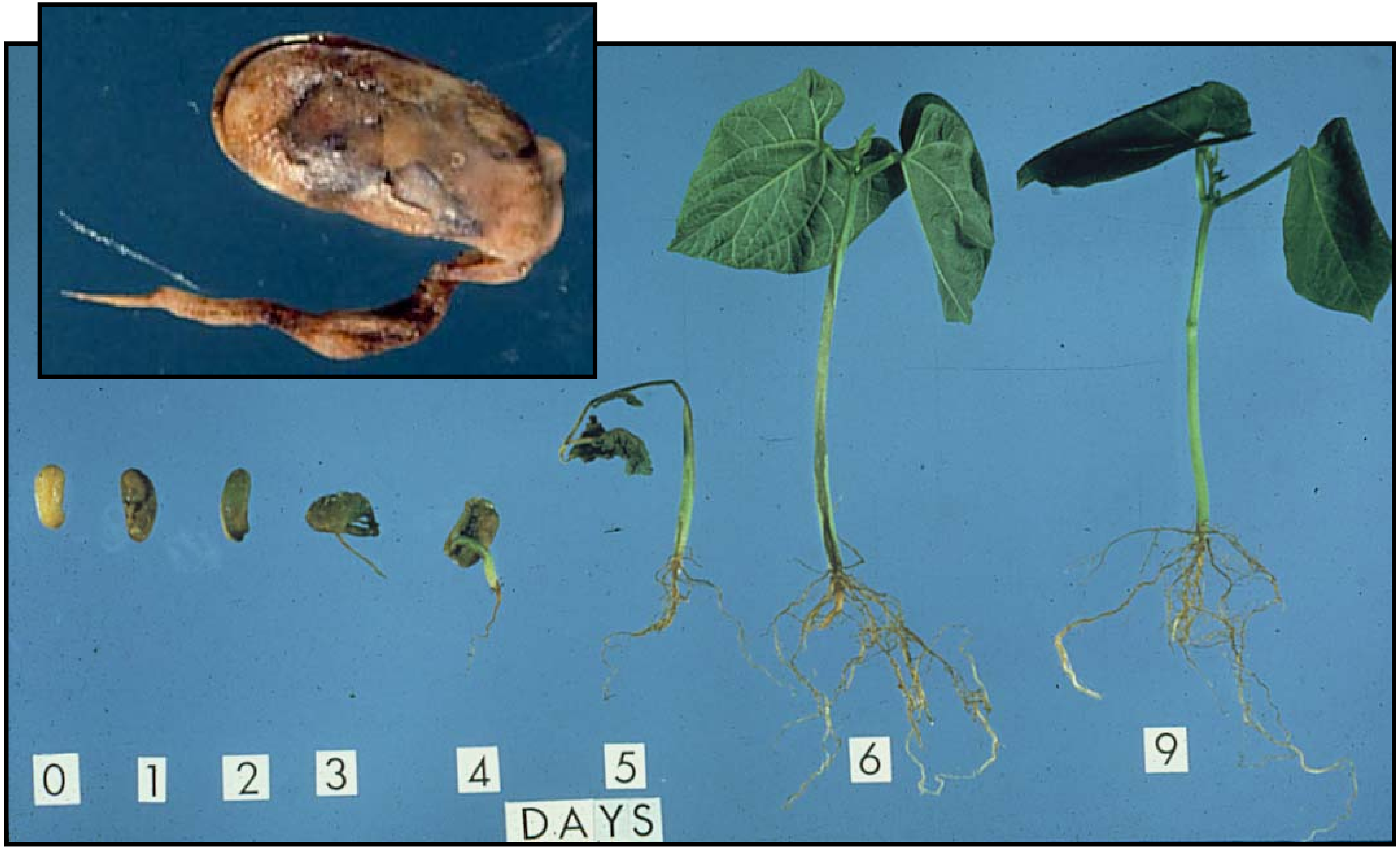
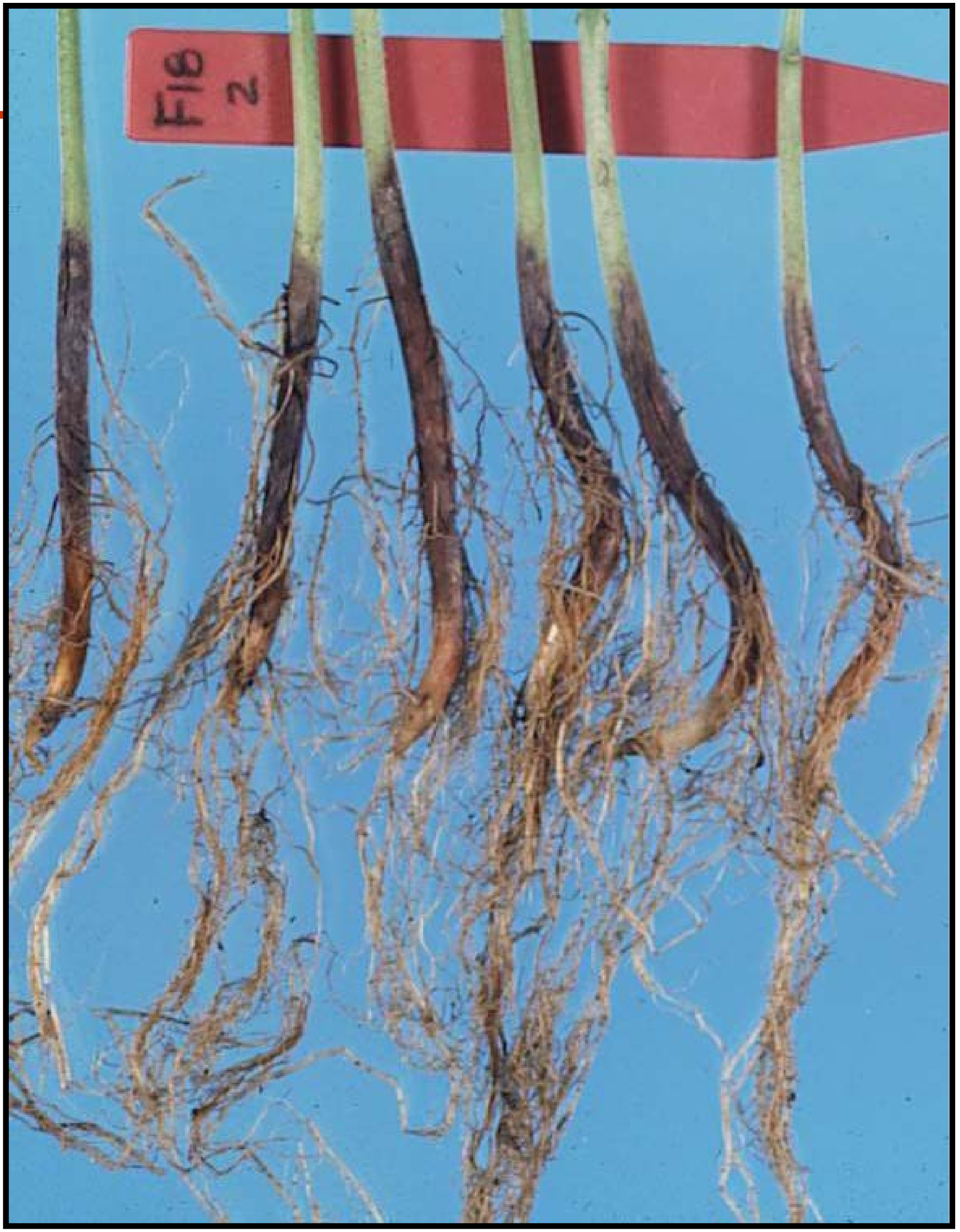
Pythium Root Rot
(*Pythium* spp.)



Fusarium Root Rot

(*F. solani* f.sp. *phaesoli*)



Fusarium solani (*F. solani* f.sp. *phaesoli*)

Fusarium Root Rot

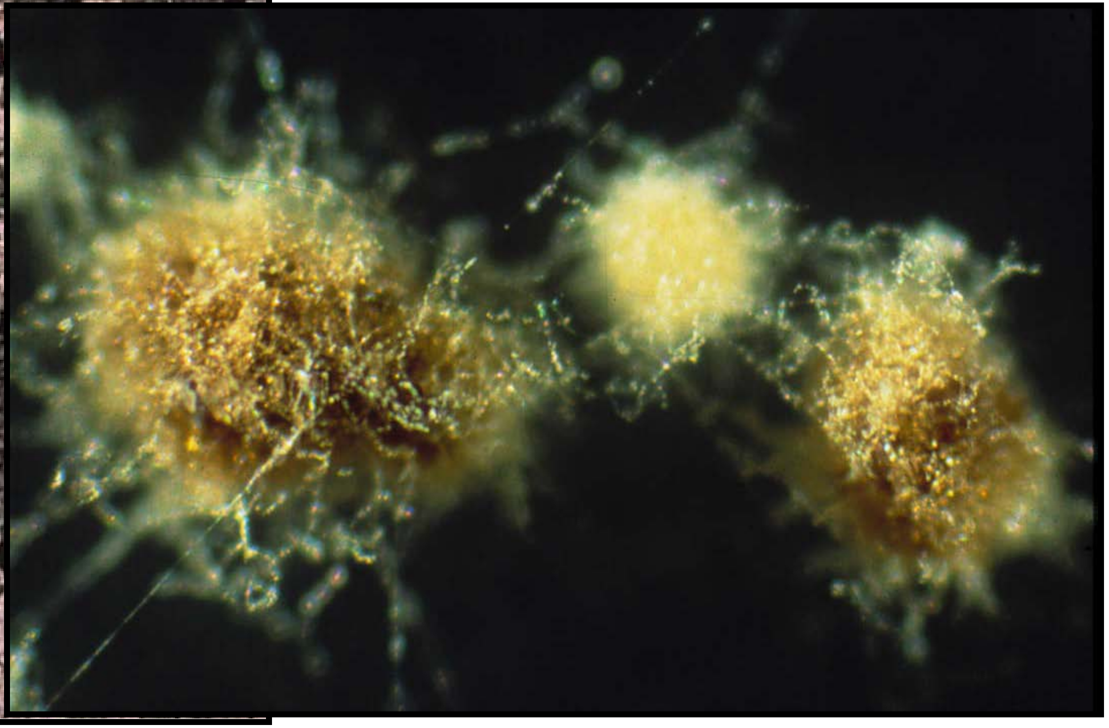
(*F. solani* f.sp. *phaesoli*)

Rhizoctonia on Beans

Rhizoctonia solani

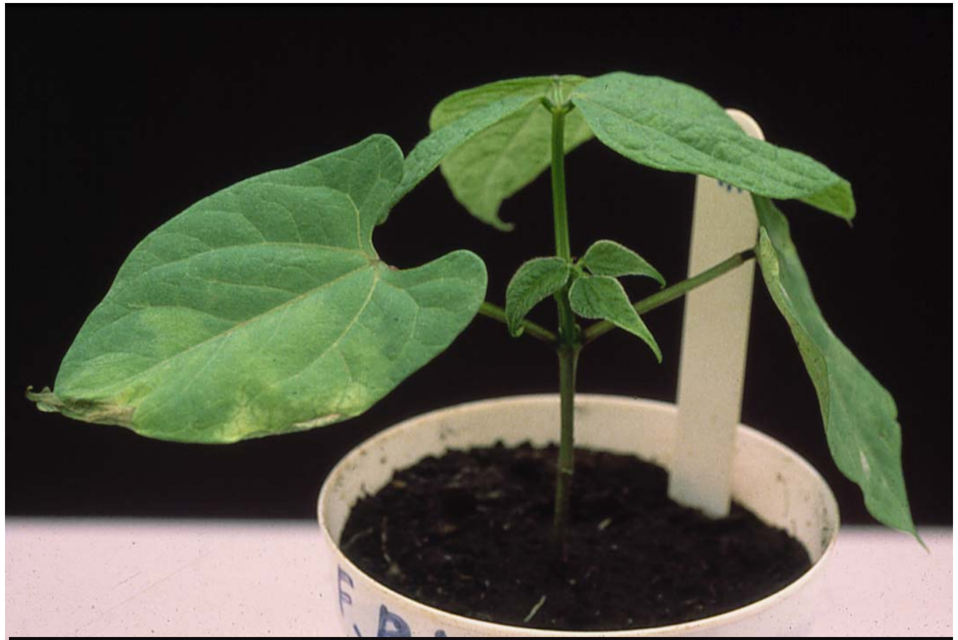
Rhizoctonia Root Rot

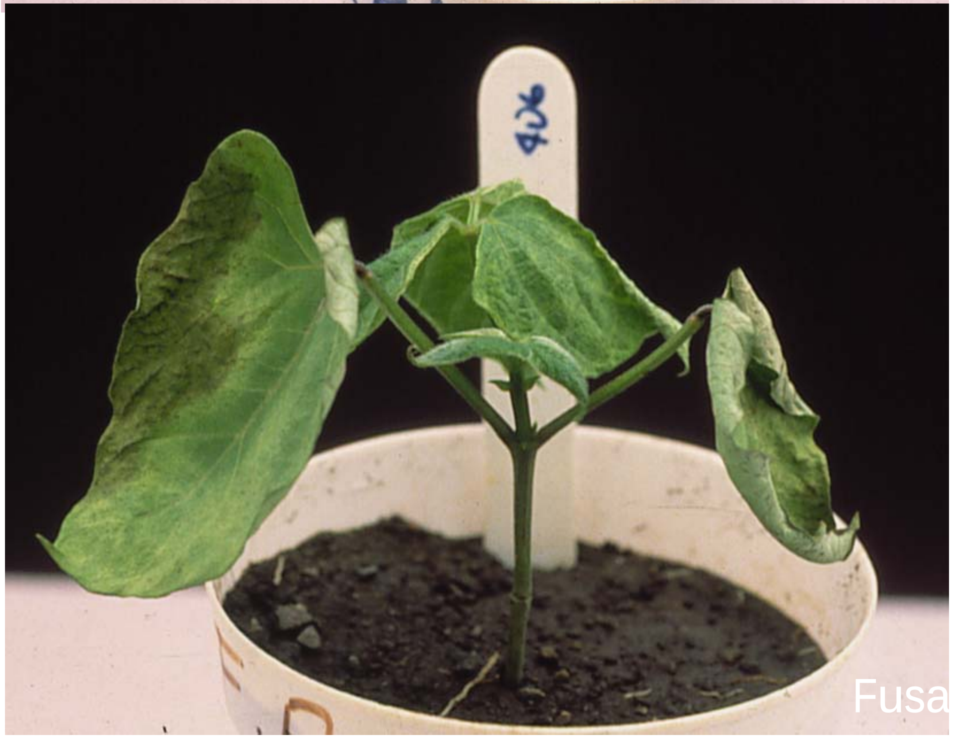
(*Rhizoctonia solani*)



Fusarium Wilt

(***F. oxysporum* f.sp. *phaesoli***)





Fusarium Wilt

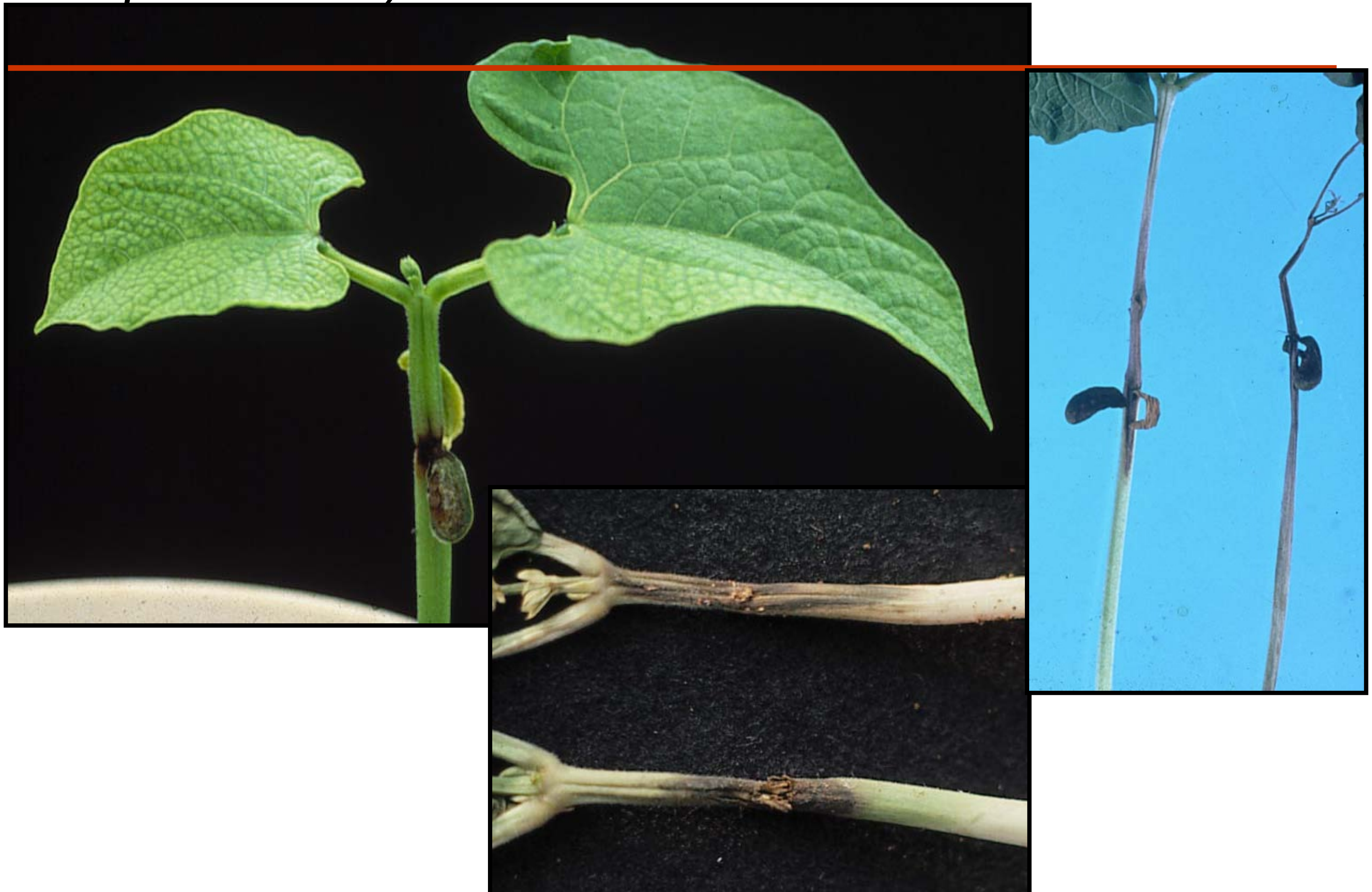
(*F. oxysporum* f.sp. *phaesoli*)

Fusarium Wilt (*F. oxysporum* f.sp. *phaesoli*)

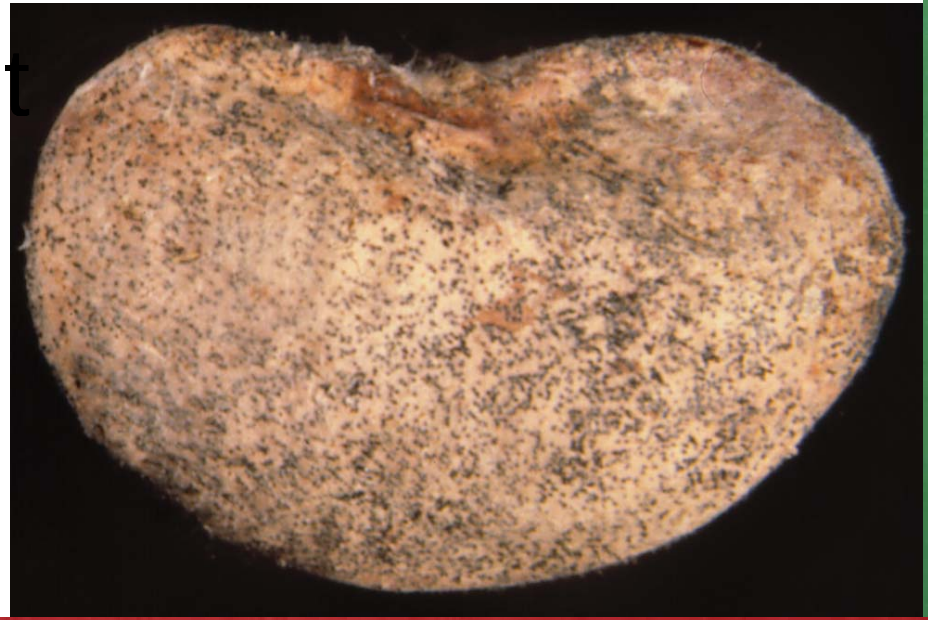
Charcoal Rot
(*Macrophomina phaseolina*)

Charcoal Rot

Macrophomina phaseolina)



Charcoal Rot
(*Macrophomina phaseolina*)



Southern Blight

(*Sclerotium rolfsii*)

Web Blight

(*Thanatephorus cucumeris*)

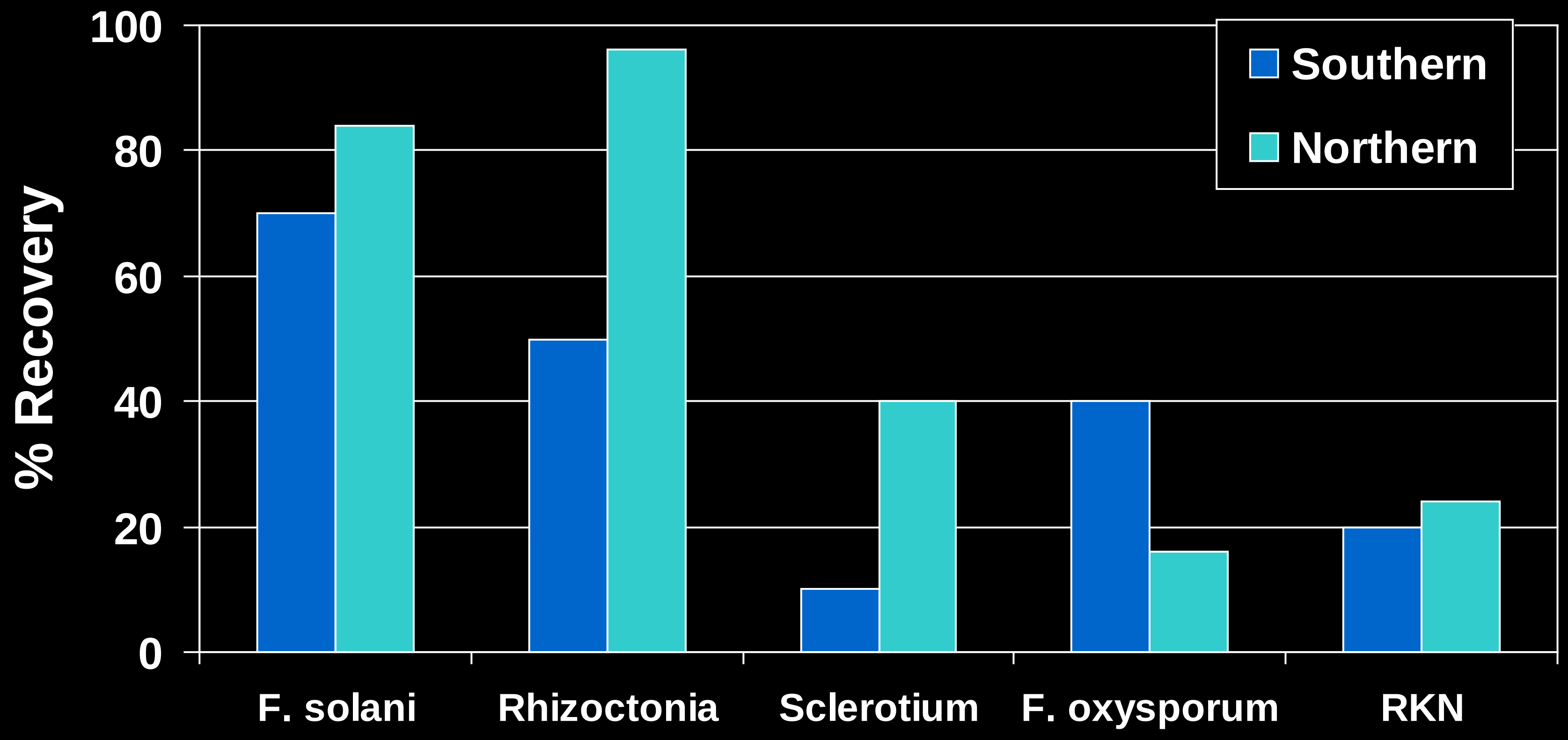
UNDERSTANDING THE ROOT ROT PATHOGENS

Importance & distribution of major root pathogens of bean

Pathogen	NE Brazil	Coastal Peru	Colombia: Popayan	Colombia: Quilichao	Colombia: Pasto Ipiales	USA (NY)	Puerto Rico
F.s. f.sp. *phaseoli*		XX	X			X	XXX
F.o. f.sp. *phaseoli*	XXX				XXX		X
Macrophomina phaseolina	XX	X		XXX			
Meloidogyne spp.		XXX					
Pratylenchus spp.						X	
Pythium spp.						XXX	XX
Rhizoctonia solani		XXX	XXX			XX	XX
Sclerotium rolfsii					X		
Thielaviopsis basicola						XX	

Bean Growing Regions

Recovery of selected pathogens from bean production areas of Ecuador. Nov 06 & Apr 07.



Variability in incidence and severity of root pathogens in bean fields in Ecuador. Nov 06.

Field	*F.solani*	*Rhizoc.*	*Sclerot.*	*F. oxysp.*	RKN	Insects
1	-	+++	-	-	-	-
15	+	+	+++	-	+	-
16	+	+	-	-	-	+++
17	+	+	++	-	+	++
18	+	+	-	+++	-	-
19	-	+++	+++	-	-	+
20	+	++	+++	-	-	+
21	-	+	+++	-	-	-
24	+	+	-	++	-	++
25	+	+	-	-	-	-
27	-	-	-	+	-	++

Abawi et.al, 2007)

Root Rot complex in Puerto Rico

- *Fusarium solani* is associated with discoloration of the tap root and tan lesions in the hypocotyl and severe root rot.

- *Fusarium oxysporum* is in a complex associated with *Fusarium solani* and *Pythium* spp.

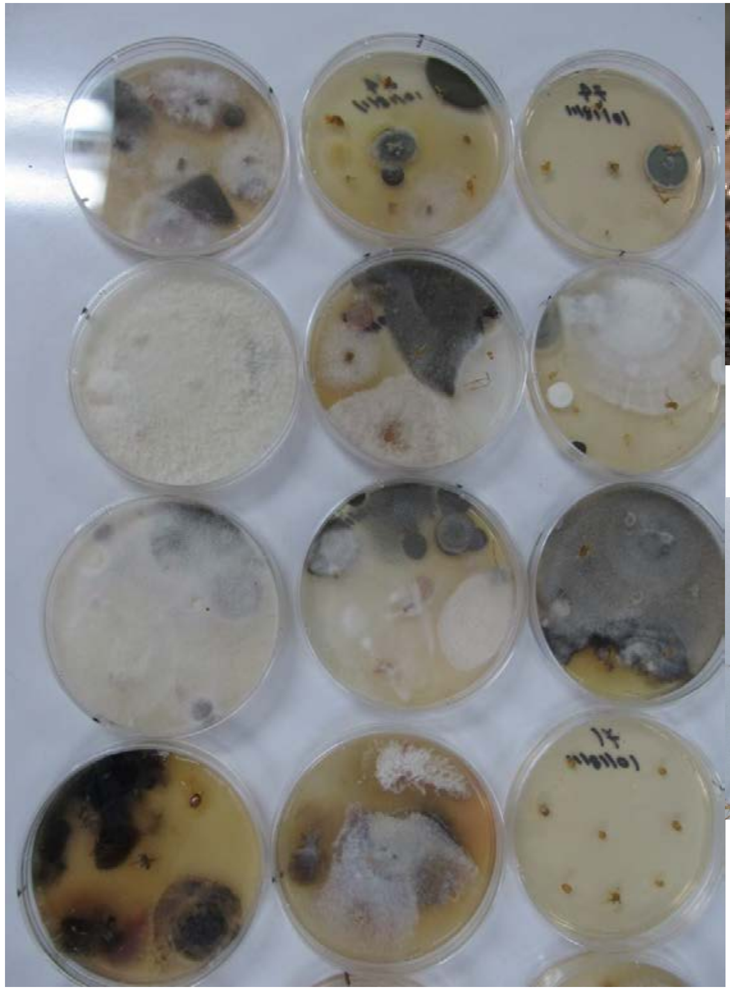
- *Rhizoctonia solani* is important in the dry season producing hypocotyl rot.

- Isolations of *Pythium* spp. in common beans are common in V3 stage producing hypocotyl rot (*Pythium graminicola*, *Pythium ultimum* *Pythium miriotyllium*, *Pythium sp.*

Estevez de Jensen, 2015

Frequency of fungi and Oomycetes , 2015, Puerto Rico

- *Rhizoctonia solani* 13%
- *Fusarium solani* 31%
- *Pythium sp.* 22%
- *Fusarium oxysporum* 10%
- *Fusarium spp.* 11%
- *Macrophomina phaseolina* 3 %
- *Sclerotium rolsfsii* 5%
- *Bacteria* 2 %
- Unknown 3%



Estevez de Jensen, 2015

Summary:

1. *R. solani* and *F. solani* f. sp. *phaseoli* were the most prevalent, but also *S. rolfsii*, *F. oxysporum* f. sp. *phaseoli* and *Meloidogyne* spp.

2. *R. solani* and *S. rolfsii* were more prevalent in the northern production region, whereas *F. oxysporum* f. sp. *phaseoli* was more prevalent in the southern region.

3. The incidence and damage severity of root pathogens varied among fields in the same region.

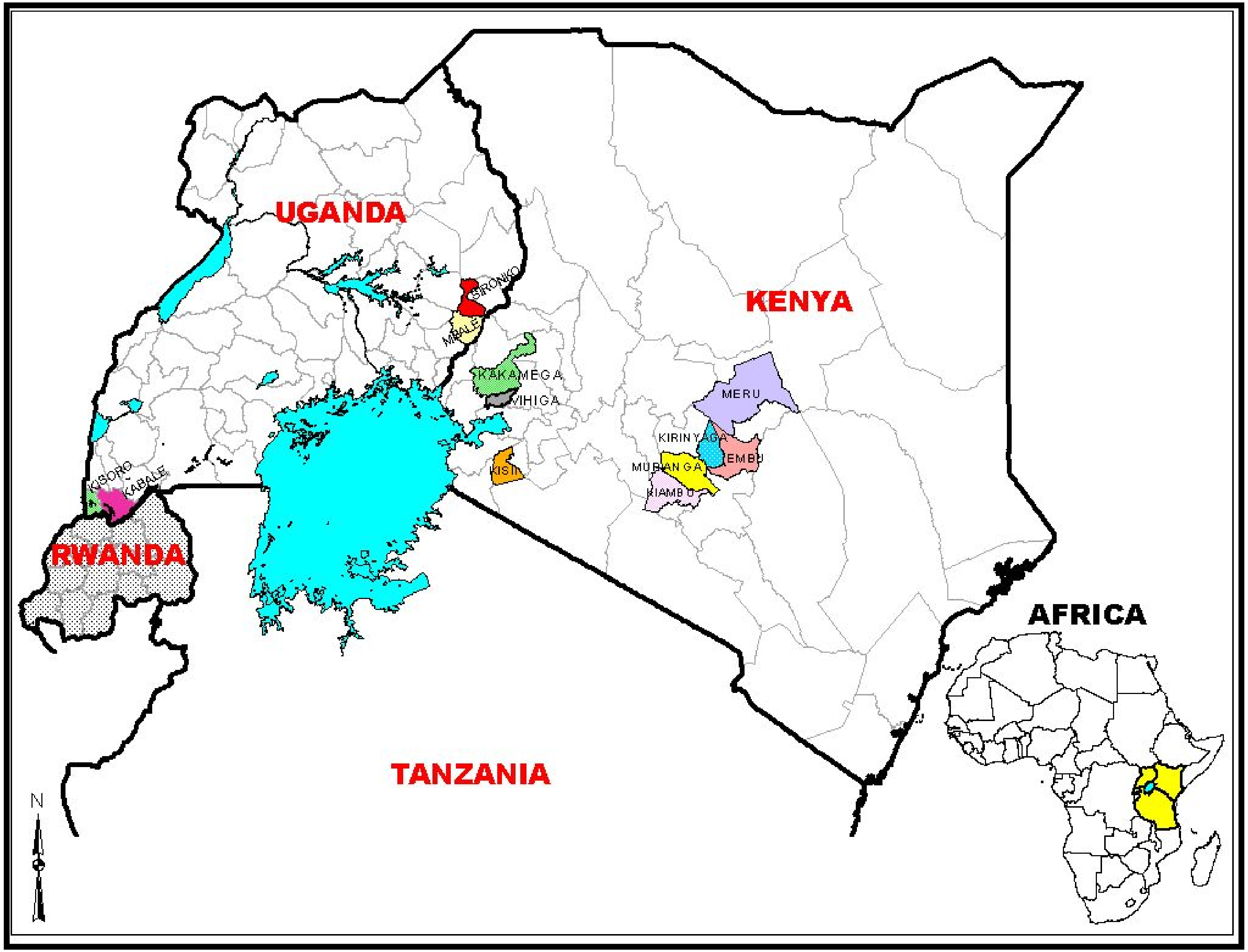
4. In Puerto Rico, *F. solani* f. sp. *phaseoli* Pythium spp and *R. solani* were the most prevalent pathogens

Important Fungal and bacteria bean diseases in Africa

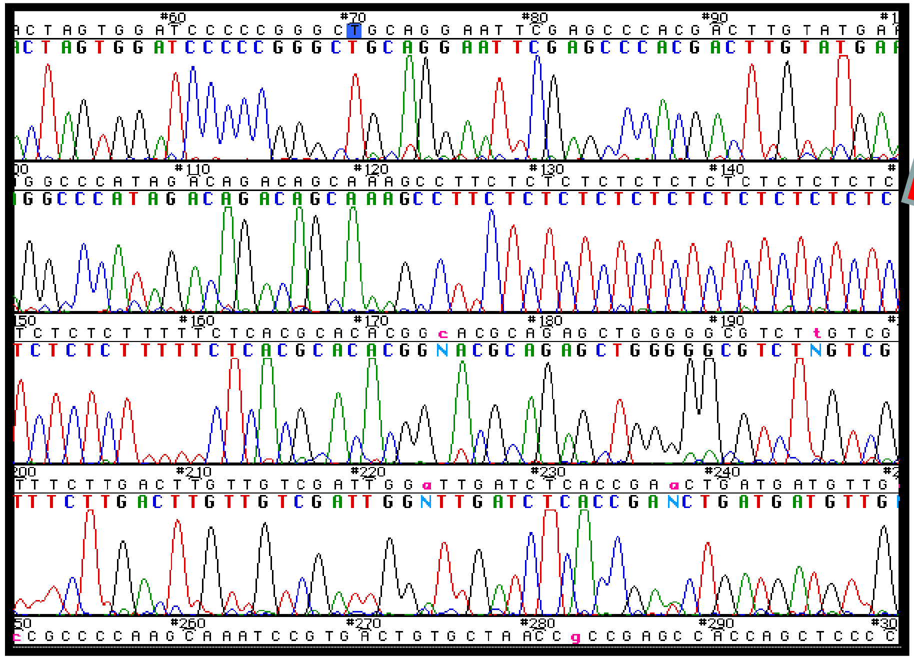
Disease	Africa	Yield Loss (000 t)
ALS	*** +++	384.2
ANTH	*** ++	328.0
CBB	*** ++	220.4
Root rots	*** ++	221.1
Rust	*** ++	191.4
Ascochyta	** +	169.2

** economic importance
++ distribution

Root Rot Prevalent Areas (East Africa)



Pythium species identified by morphological, sequencing pathogenicity on beans



Reaction of AND 1062, RWR 719 and susceptible CAL 96 and LRK 33-1 following inoculation with *P. ultimum*

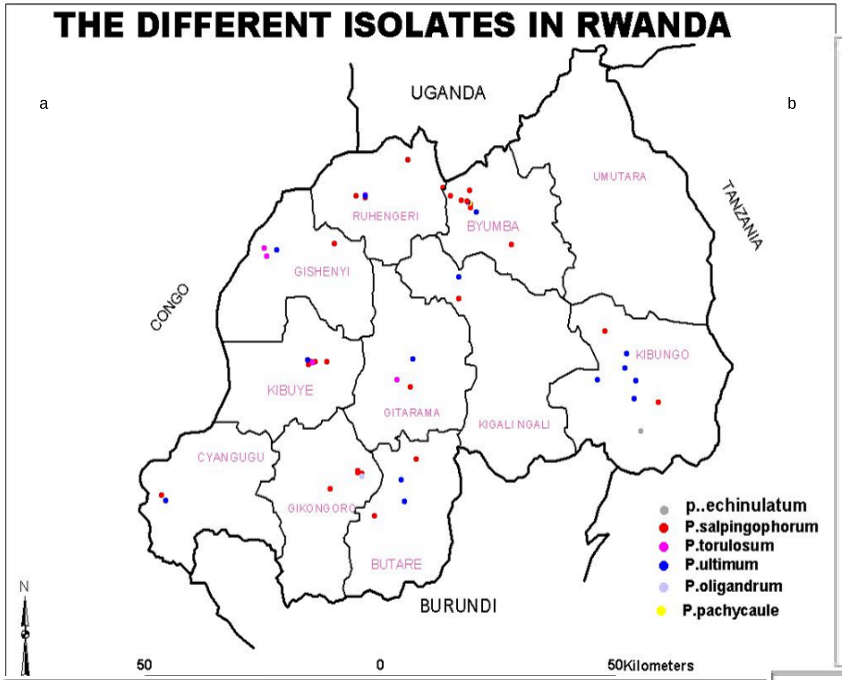
Species of *Pythium* characterized by sequencing of ITS1 Region of rDNA

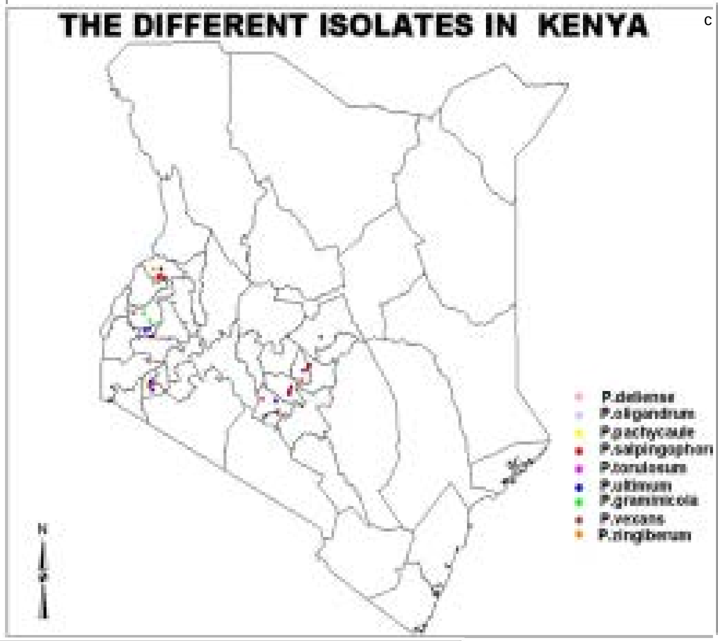
	Isolates			
Pathogenic Species	**Uganda**	**Kenya**	**Rwanda**	**Total**
P. ultimum	**17**	**9**	**23**	**50**
P. aphanidermatum	**1**		**1**	**2**
P. irregulare		**9**	**1**	**10**
P. myriotylum		**1**	**1**	**2**
P. torulosum	**8**	**11**	**10**	**29**
P. salpingophorum	**12**	**1**	**4**	**17**
P. spinosum	**7**	**1**	**7**	**15**
P. pachycaule	**3**			**3**
P. graminicola		**7**		**7**
P. nodosum	**2**			**2**
P. paroecandrum		**3**	**3**	**6**

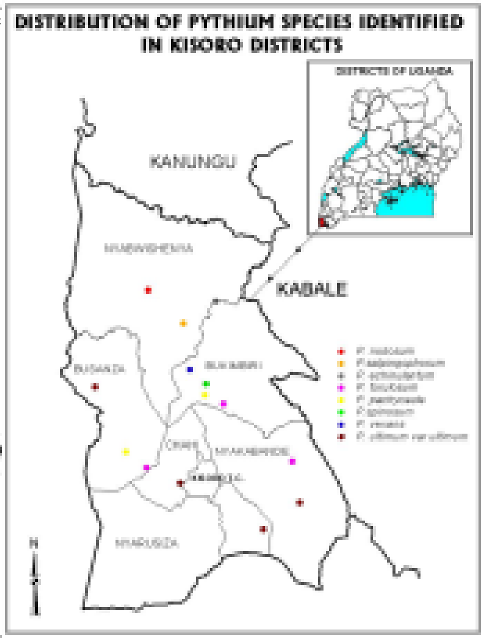
Pathogenicity of *Pythium* species (identified using sequence analysis) on bean varieties CAL 96, K20 and RWR 719

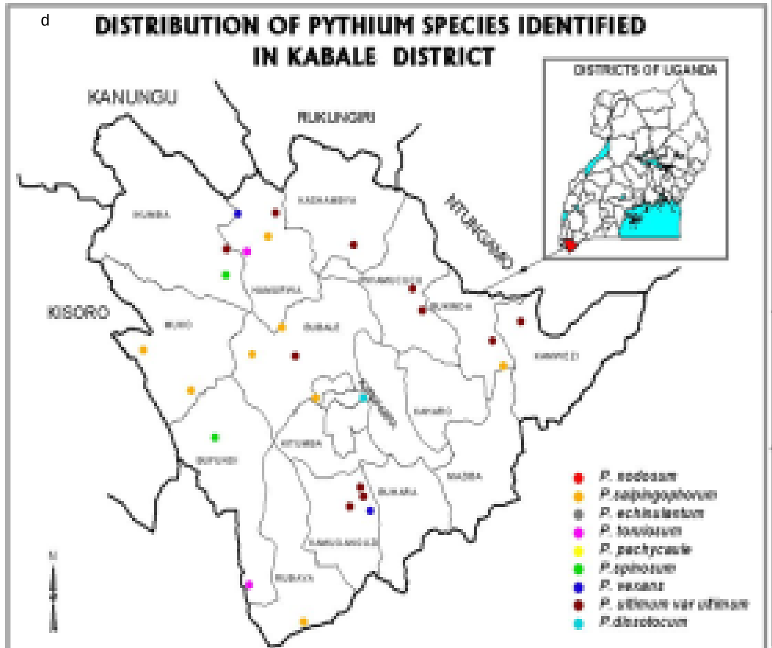
Species	Isolate	Disease severity		
		CAL 96	K 20	RWR 719
Pythium spinosum	KAB 4	8.9	8.6	6.3
	KAB 5	6.6	5.7	4.1
	MS 34	8.7	8.6	3.8
P. torulosum	KIS 14	9.0	7.7	3.8
	KIS 5	8.2	8.1	3.9
	KAB 28	8.8	8.2	4.7
P. salpingophorum	KAB2	7.8	7.3	6.0
	KAB13	8.8	8.2	6.1
	KAB26	4.9	3.9	4.1
Pythium ultimum	KAB8	9.0	9.0	2.7
	MS 1	9.0	9.0	5.8
P. pachycaule	KIS 6	8.2	7.8	3.7
P. nodosum	KIS 3	7.4	6.6	4.3
P. echinulantum	KIS 4	5.4	3.9	4.3
	Control	1.0	1.0	1.0
LSD p= 0.05			1.6	

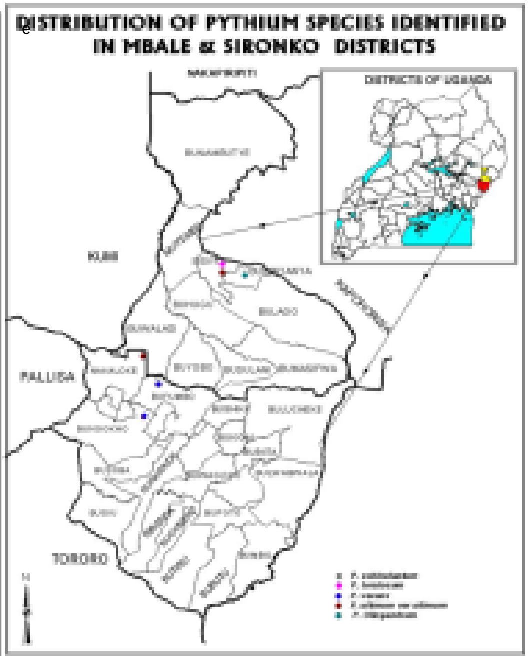
Distribution of Pythium spp in Kenya, Uganda and Rwanda











- 29 Pythium spp identified
- *P. ultimum*, the most widespread pathogenic spp
- Distribution maps developed.

Summary

- Types
  - *Pythium* spp ****
  - *Fusarium solani* fsp *phaseoli* **
  - *Fusarium oxysporum* fsp *phaseoli* ***
  - *Rhizoctonia solani*
  - *Macrophomina phaseolina*

- Occurrence in complex of two or more (Rusuku *et al.,* 1997)

- Pythium most important

- Some root rot pathogens on beans have been associated with other crops in the bean cropping system (Gichuru et. al.,. 2008)

- Some Pythium spp. pathogenic to beans produced varying levels of disease symptoms in sorghum and millet

Mukalazi e.al., 2004) Tusiime et.al 2004; Buruchara et al. 2006, Gichuru et. al. 2008)

Impact on germplasm diversity

- Rwanda
  - Conscious shift from bush to climbers
  - Shift from local to improved tolerant varieties
  - Shift from large to small seeded
  - Reduction in size and composition of mixtures

- South West Uganda
  - 2001 survey: 50% stopped growing large and 40% medium size traditional varieties in certain seasons
  - 48% introduced small sized cultivars tolerant to root rots
  - Andean varieties - very susceptible

Management Strategies

A number of management options have been observed to be effective in controlling root rots of beans (Abawi and Pastor-Corrales,1990).

A. Genetic / germplasm improvement
   - ✓ Appropriate to small-scale farmer.
   - ✓ In preferred & diverse backgrounds
   - ✓ Multiple constraint resistance
B. Cultural
   - ➢ Reduce inoculum population
   - ➢ Fertility improvement
     A. Organic and inorganic amendments
C. Integration of genetic and non-genetic options

Approach (Genetic)

A. **Identification of resistance sources**
   - ✓ **Characterization of pathogens or hot spots**
   - ✓ **Evaluate nurseries (Core Collection, IBN, SOH, VIFURE, Lamb Collection etc., local germplasm)**
   - ✓ **Artificial inoculation (screen house) or/and field evaluations**

B. **Availing resistance germplasm to end users**
   - ✓ **Root rot resistant nursery**
   - ✓ **Participatory variety selection approaches**

C. **Combining resistance and development of diverse materials**

D. **Improvement of resistance of popular and well adapted local varieties and market classes**

Evaluation of ADP's - *Rhizoctonia solani* (Puerto Rico)

Disease Severity scale

Evaluation of ADP's - *Rhizoctonia solani*

- Single hyphal tip
- Potato-Dextrose-Agar (acidified)
- Inoculation 1 agar disk/seedling
- Evaluation 7 days after inoculation
- Disease severity scale (1-9)

  1 = healthy plant

  3 = necrotic lesions in the hypocotyl

  5 = 25% of the hypocotyl area with lesions

  7 = 50% del hypocotyl area affected and root rot

  9 = dead plant


ADP 518
ADP 633
VERANO


ADP 54
ADP 115
ADP 475

Evaluation of ADP's – Root rot

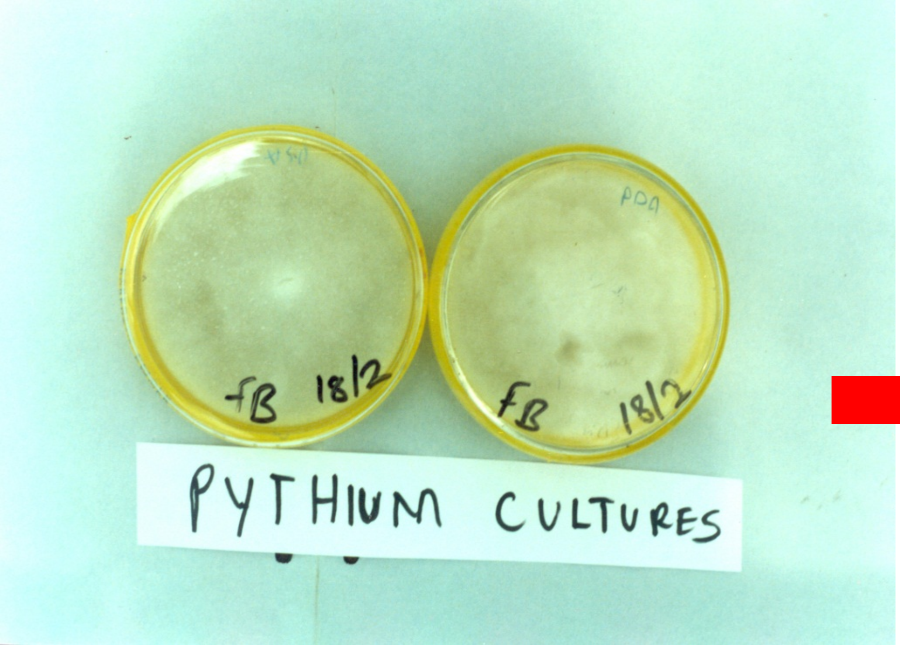
< 4.0	> 7
R	S
ADP 724	ADP 106
ADP 54	ADP 676
ADP 20	ADP 80
ADP 469	ADP 98
ADP 269	ADP 35
ADP 383	ADP 368
ADP 737	ADP 540
ADP 633	ADP 465
ADP 508	ADP 186
ADP 723	ADP 478
ADP 518	ADP 685
ADP 620	ADP 719
ADP 637	ADP 741
ADP 475	Verano
ADP 115	
ADP 721	

Disease severity scale (1-9)

- Resistant lines 1, 2 y 3
- Intermediate reaction 4, 5 y 6
- Susceptible 7, 8 y 9

Lines evaluated 254

Mean	5.5	7.3
Sign	NS	0.0002
LSD		2.0
CV		16.8

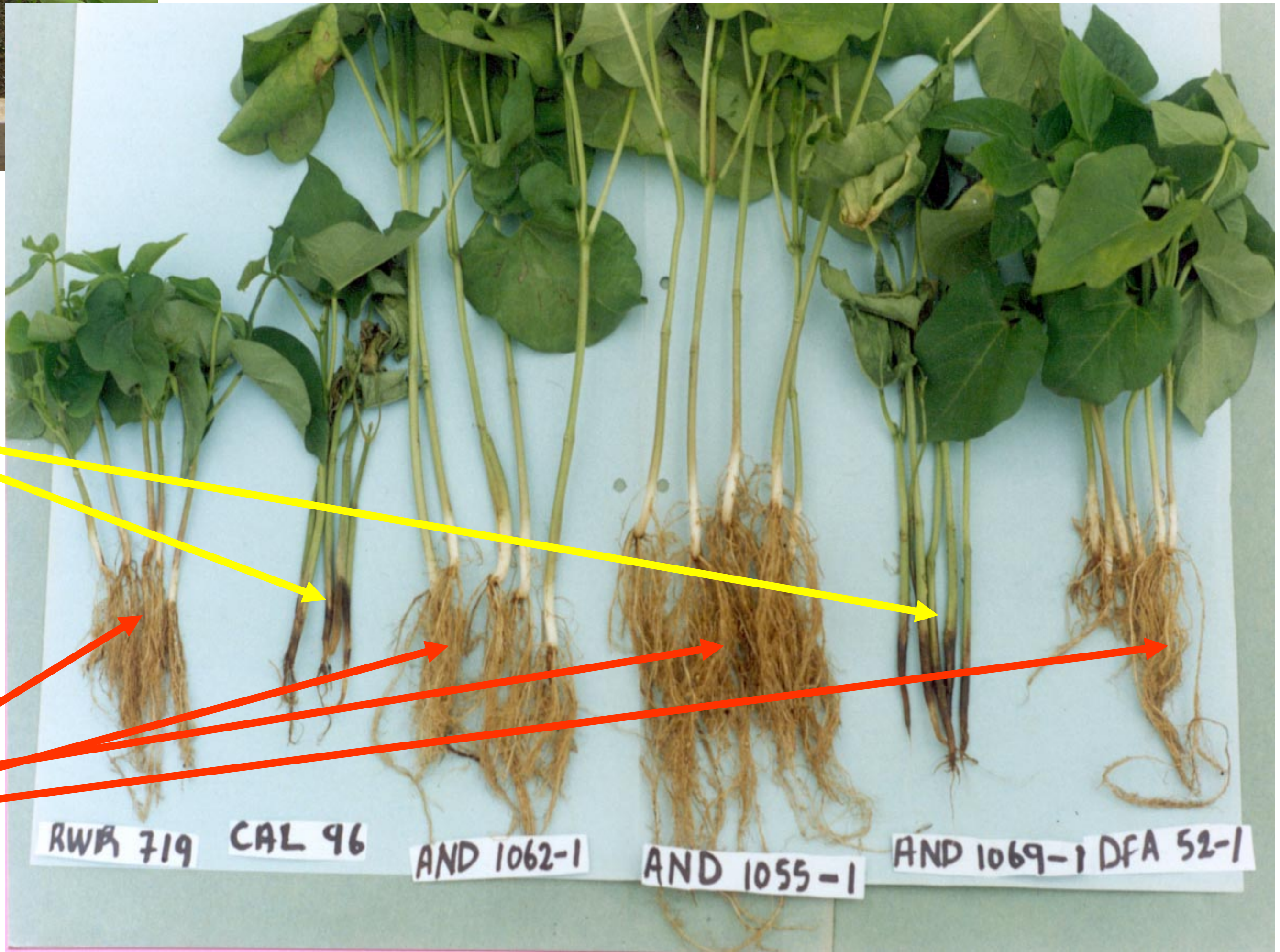

PDA
fB 18/2
fB 18/2
PYTHIUM CULTURES


15/2/200
PYTHIUM INOCULUM
PREPARED ON
FINGER MILLET

Screenhouse Evaluations germplasm against Pythium

Susceptible

Resistant

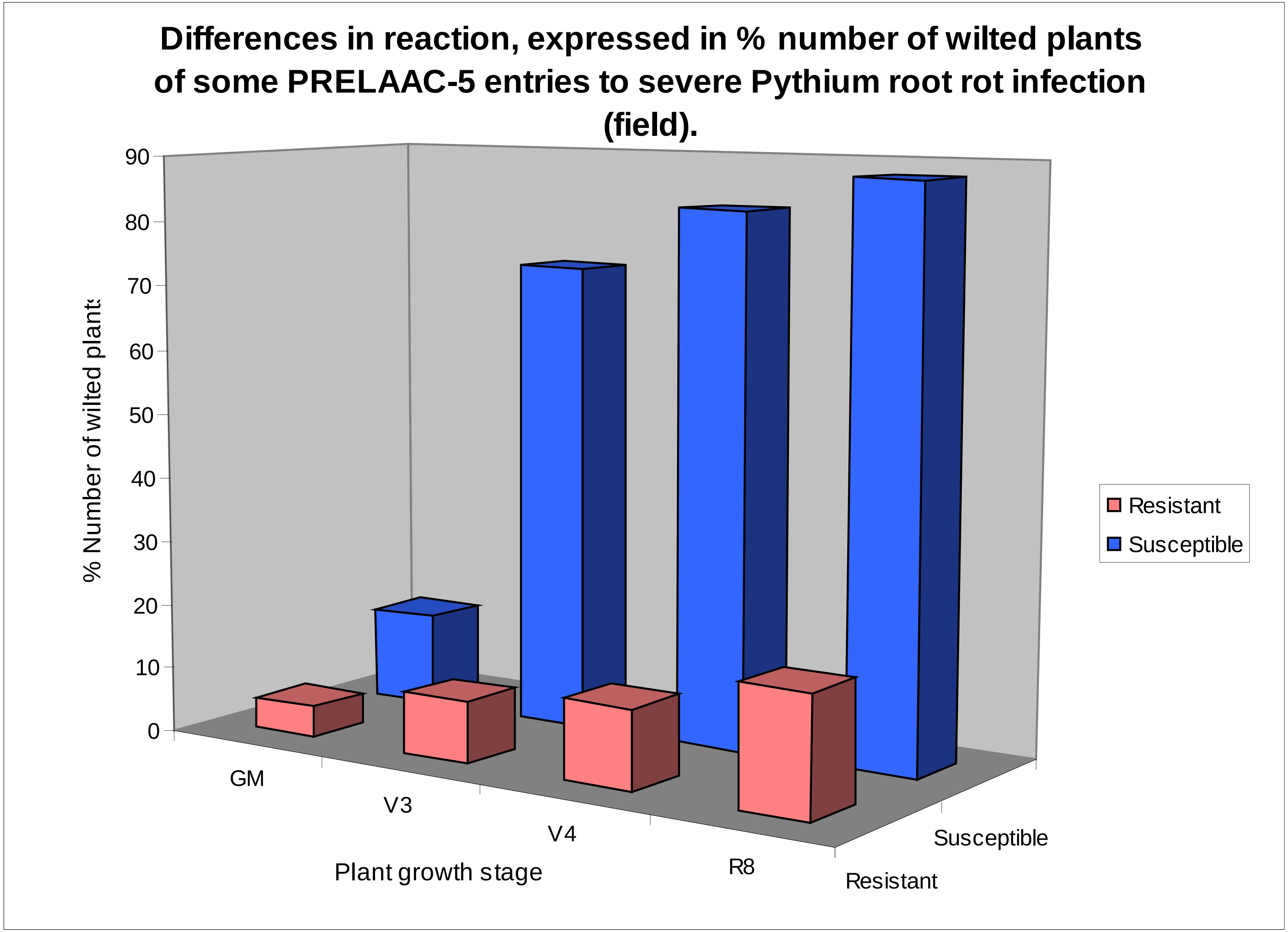


Field Evaluations

Rwanda

Reaction, expressed in cumulative number of wilted plants and yield of selected entries to severe root rot[x] infection (1992A season, Rubona, Rwanda).

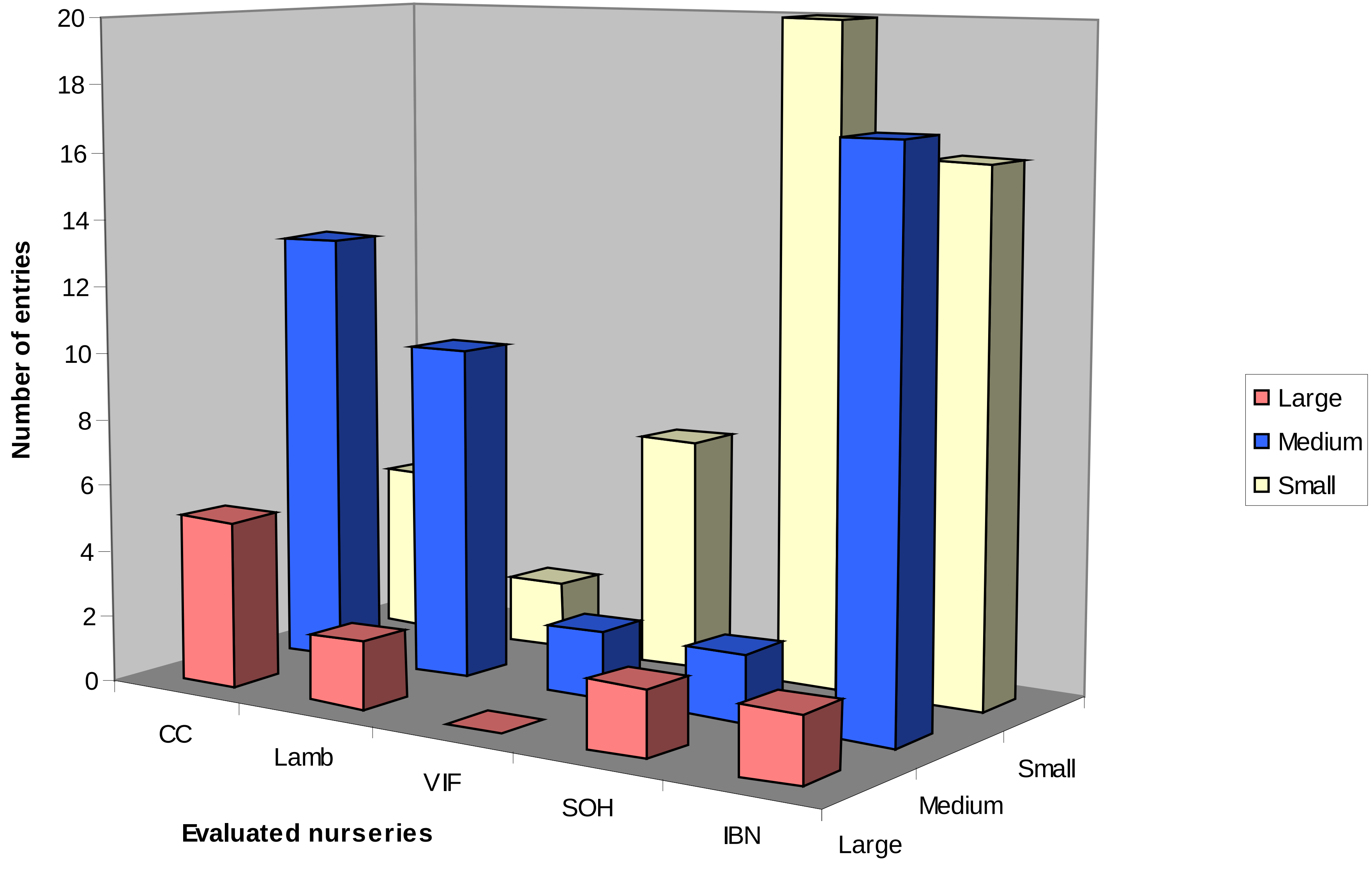
Class	**Variety**	**% No. of wilted plants**				**Yield (kg/ha)**
Resistant		GM	V3	V4	R8	
	MLB-49-89A	2.2	9.3	10.0	14.3	1440
	MLB-43-89A	7.1	8.6	9.3	14.3	1056
	MLB-48-89A	5.0	8.6	12.9	23.8	1124
	RWR 719	7.1	10.7	12.1	13.6	862
Susceptible						
	RWR 306	13.6	79.3	90.7	92.1	148
	RWR 713	16.4	87.9	91.4	93.6	89
	EM/27/4	15.7	62.9	74.3	85.0	101
	MLB-31-88B	13.6	80.7	90.0	90.0	73


Differences in reaction, expressed in % number of wilted plants of some PRELAAC-5 entries to severe Pythium root rot infection (field).
90
80
70
60
50
40
30
20
10
0
% Number of wilted plants
GM
V3
V4
R8
Plant growth stage
Susceptible
Resistant
Resistant
Susceptible

Response of entries drawn from various nurseries to artificial inoculation with *Pythium* spp under screenhouse

Nursery	Entries	Disease severity classes		
		Resistant (≤ 3)	Intermediate (3.1-6.9)	Susceptible (7-9)
Core Collection	795	18	46	731
PRELAAC-3	100	8	6	86
IBN-94/96	937	12	72	853
VIFURE	147	0	14	133
SOH	914	0	53	861
Lamb Collection	291	0	14	277
Anthracnose Nursery	70	0	0	70
BILFA-IV	72	0	7	65
Adv Lines (RWA)	52	0	9	43
MCR (Red Mottle)	296	0	42	254
MCR (Red Kidney)	233	0	62	171
Local Mixtures	86	0	8	78
Total	3993	38 (1%)	330 (8)	3622 (91%)

Frequency of different seed types among resistant (36) and intermediate (300) entries to Pythium root rot from different nurseries.



Characteristics of some entries in the Regional Bean Root Rot Nursery (70)

Entry	Seed Size	Growth Habit	Origin	Disease Reaction n(Scale of 1-9)
FEB 181	S	1	CIAT	4.2
FEB 189	S	1	CIAT	2.7
FEB 195	S	1	CIAT	2.5
DOR 633	S	1	CIAT	4.0
DOR 708	S	1	CIAT	3.2
DOR 711	S	1	CIAT	3.1
DOR 755	S	1	CIAT	4.8
DOR 766	S	1	CIAT	2.8
SEA 10	S	1	CIAT	2.6
AND 1064	L	1	CIAT	3.1
MLB-17-89A	L	1	DRC	3.5
MLB-22.89A	M	1	DRC	3.3
MLB-40-89A	S	1	DRC	4.8
MLB-48-89A	S	1	DRC	5.4
MLB-49-89A	S	1	DRC	3.1
MLB-69-89A	M	1	DRC	3.3
RWR 221	S	1	Rwanda	3.2
RWR 719	S	1	Rwanda	4.2
RWR 1092	M	1	Rwanda	2.5
G 2858	S	3	Mexico	3.9
G 685	S	3	Mexico	3.5
SCAM-80CM/5	S	1	Burundi	3.7

Best performing entries on plant mortality, vigour and yield over three countries

Entry	W. Kenya	Rwanda	S. W. Uganda	S. Africa
MLB-49-89A	√√	√√	√√	√√
MLB-40-89A	√√	√√	√√	√√
RWR 719	√√	√√	√√	
SCAM-80CM/15	√√	√√	√√	
RWR 1091	√√	√√	√√	
RWR 221	√√	√√	√√	
DOR 710				
DOR 633	√√	√√	√√	
MLB-36-89A	√√	√√	√√	√√
G 685	√√	√√	√√	-
AND 1062	√√	√√		
AND 1055	√√	√√		
MLB-69-89A	√√	√√	√√	√√

Impact (Western Kenya)

- Farmer tested disseminated
- 35-80% adoption of resistant varieties
- Yield from 0-200 to 800 to 1000kg/ha
- Increased consumption
- Marketing
- Investments on food, household items, and school related expenses.

A Taking advantage of benefits of molecular tools to enhance the efficiency and effectiveness of technology development

- About 100 resistant lines out of 6000
- **Elite resistant sources: RWR 719, MLB-49-89A, AND1062, AND 1055 and SCAM 80CM/15.**
- Resistance Markers identified in RWR 719, M, MLB-49-89A and AND 1062
- Only one SCAR marker, PYAA19, in RWR 719 is useful and routinely used in MAS at CIAT Kawanda, Uganda

Genetically variable F1 populations ← - MAS used to detect presence of desirable alleles

↓

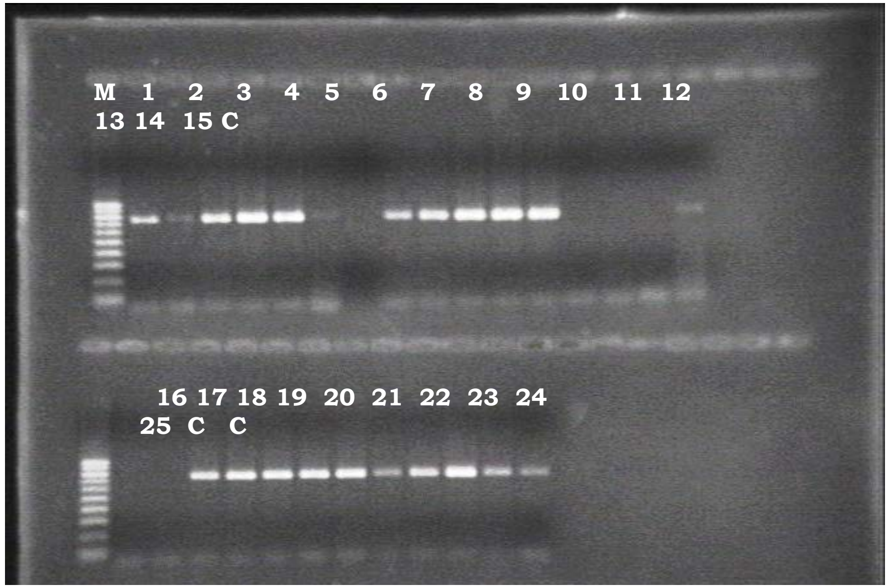
F3 population ← - Field evaluation - Application of MAS - On-station PPB

↓

F4 Population ← - Application of MAS for ALS and Anthracnose

↓

F5 Population ← - On-station PPB - Seed increase of the MAS selected individual plants



Identified SCAR markers linked to Pythium root rot resistance genes

Disease	Marker	Size bp	Gene	Resistance Source
Pythium root rot	**PYAA19**	**800**	***co-dominant***	**RWR 719**
Pythium root rot	**PYBA08**	**350**	***co-dominant***	**RWR 719**

Summary

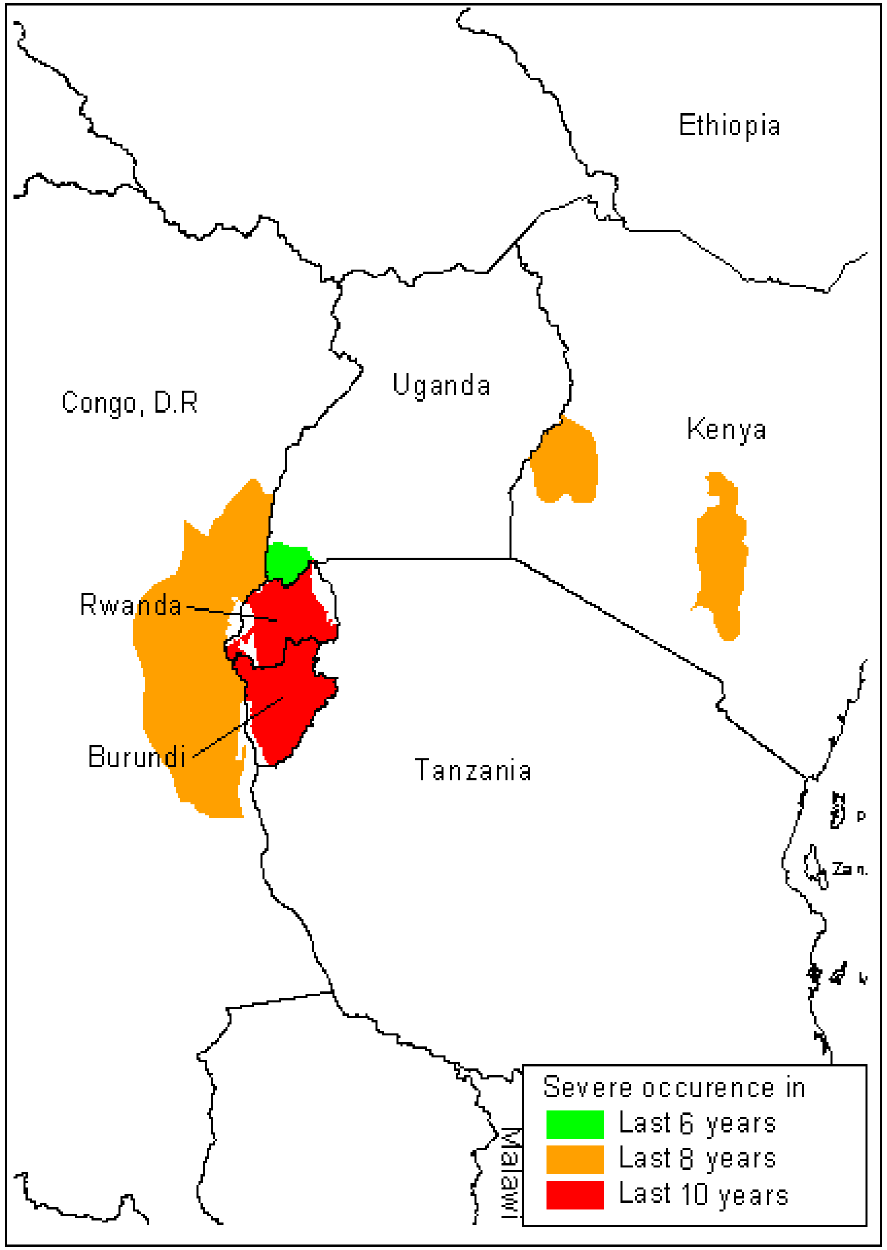
- Resistance against Pythium spp identified
- Few sources of resistance (2% of 6,000)
- Resistance sources over space and time and acceptable by farmers are: MLB-49-89B, RWR 719, SCAM-80CM/15, RWR 1092, MLB-40-89A)
- Most released cultivars susceptible
- Marker identified for the resistance line RWR 719

Non Varietal Management:

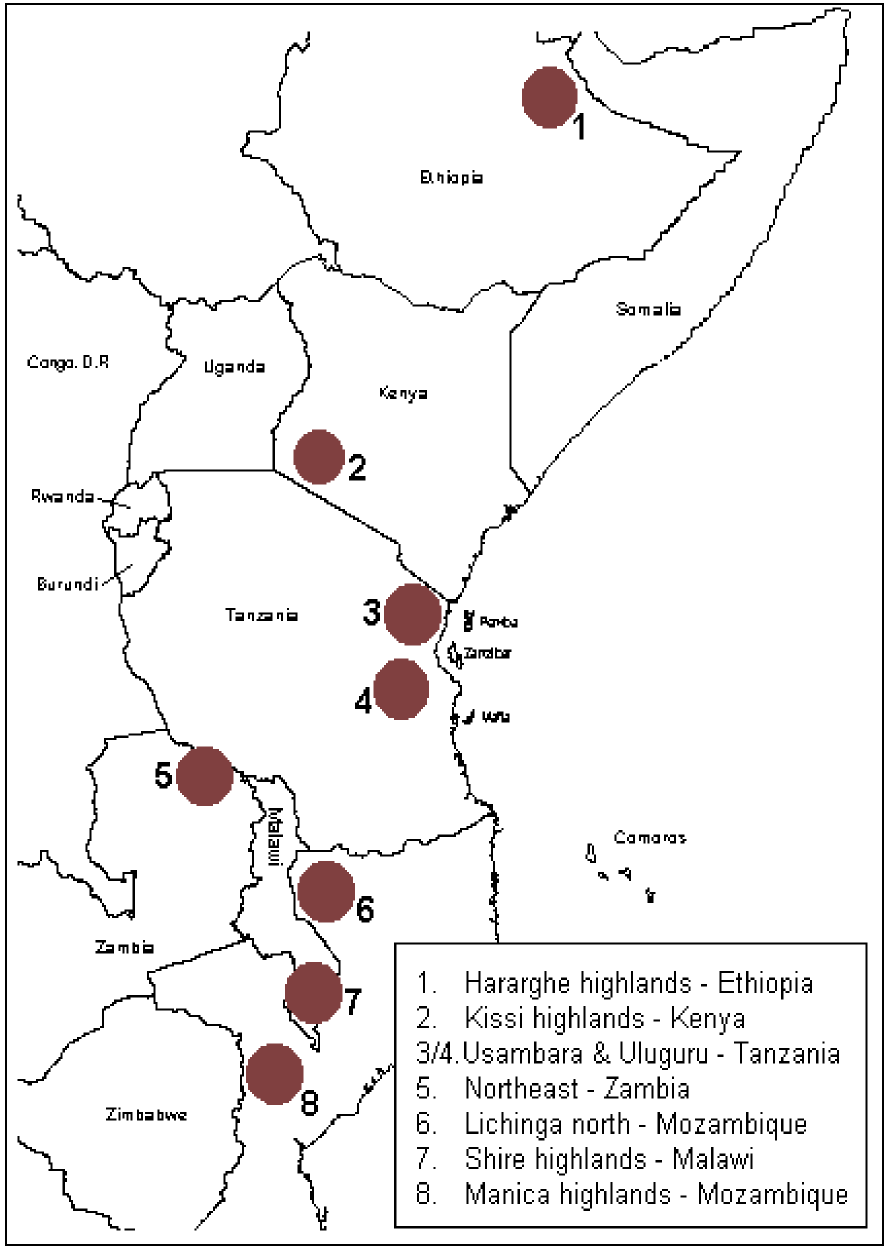
Effect of organic and inorganic amendments and variety on bean root rots, (CIAT, Uganda, 2001)

Treatment	Plant Mortality(%)	Yield kg/ha
Farmer Var. + 0	86	0
Farmer Var. + FYM	70	320
Farmer Var. + NKP	36	720
MLB-49-89A + 0	0	500
MLB-49-89A + FYM	0	920
MLB-49-89A + NPK	0	1260

Actual and Predicting Model of Occurrence

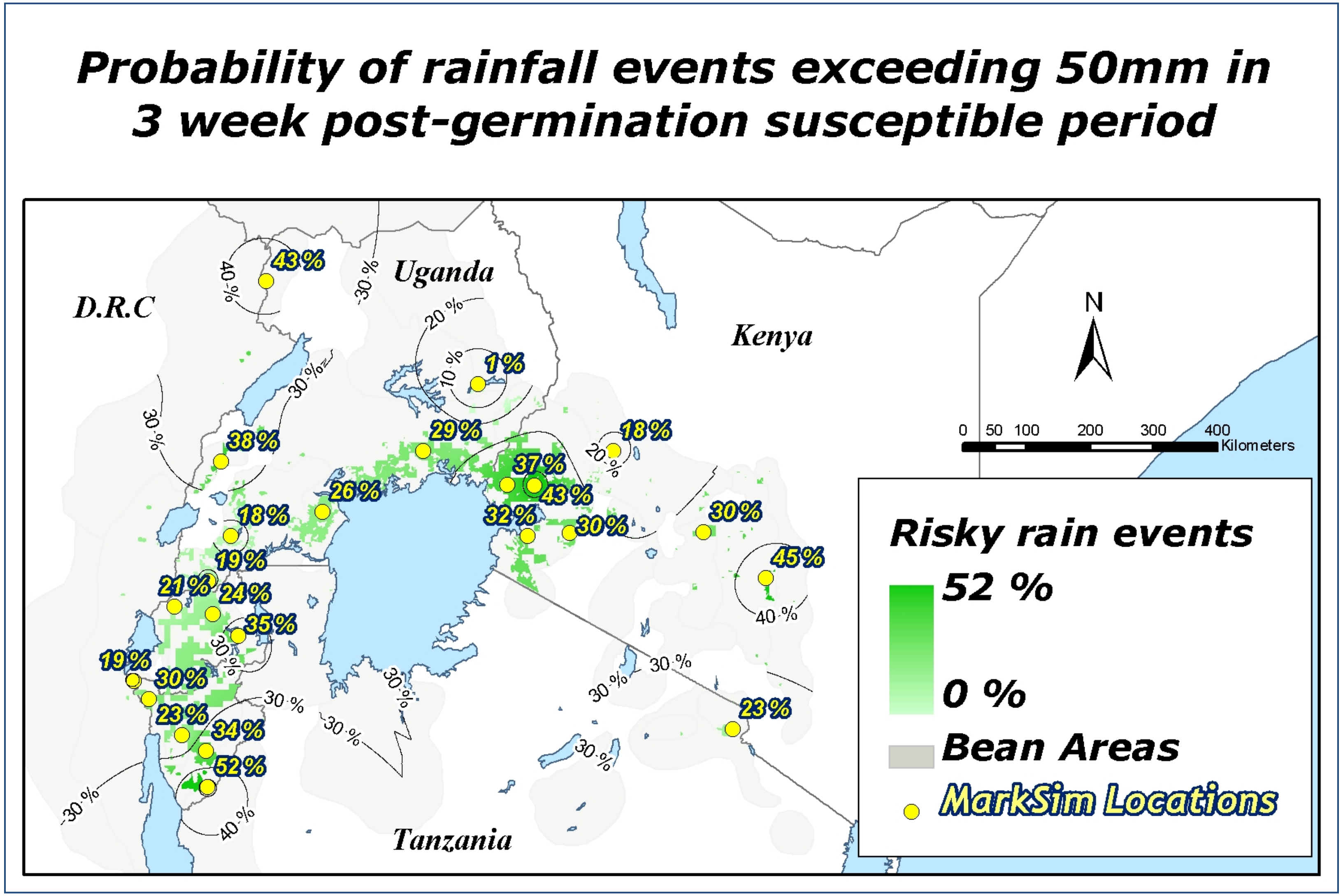


Map1 Severe Occurrence of Bean Root Rots



Map2 Areas where Root Rot severity may be underestimated or worsen in the future

Climatic component of Root rots constraint mapped



Farrow Andy, 2010

Targeting using expert knowledge

PABRA Climate Change meeting, Arusha, March 2010

- Expected changes in disease incidence and severity:
  - High disease pressure under **excessive wet weather**
    - ALS, ANT, RR, FLS, WEB
  - High incidence of diseases under **drier conditions**
    - Macrophomina, rust, CBB, BCMV
  - Monitor emergence of new strains and more races
    - ALS, ANTH, rust, HB and RR

Future Research

- Mapping types and distribution of key root rot pathogens
- Identification of better sources of resistance
- Define methods for monitoring populations
- Understanding basis for certain management effects and practices e.g.. use of amendments to better refine them
- Interaction between beneficial microorganisms and pathogens and enhancing their potential
- Exploit biological, ecological, systems design in managing the root rots.

THANKS FOR LISTENING