Strategies for the Management of Cactus Pear Diseases: A Holistic Perspective

Wijnand J. Swart
Division of Plant Pathology
Department of Plant Sciences, UFS

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Outline of Presentation

INTRODUCTION

- Intensive cultivation of *Opuntia ficus-indica* varieties has resulted in appearance of numerous new disease problems over the past 3 decades in SA.

- Few major diseases of cactus pear (CP) reported in the world; most pathogens cause minor yield losses.
- Usually associated with bad management practices leading to opportunistic/secondary infection.

Significance of CP diseases

- Limit cultivation of CP and associated industries in certain geographic areas;
- Reduce the quantity and quality of plant products derived from the crop;
- Can make products poisonous to humans and animals;
- Cause direct and indirect financial losses.

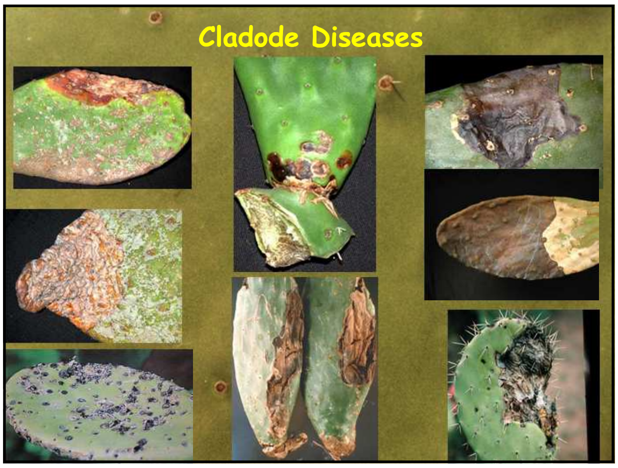
The Cryptic nature of CP diseases

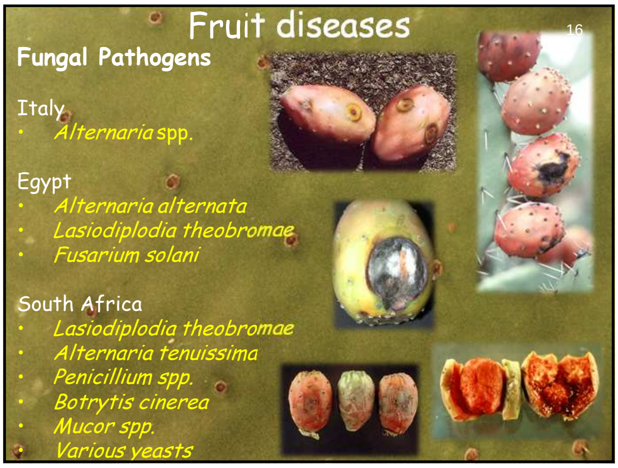
- Very few systematic studies on etiology of CP diseases and their management.
- Micro-organisms associated with visible symptoms often based on tenuous ID's.

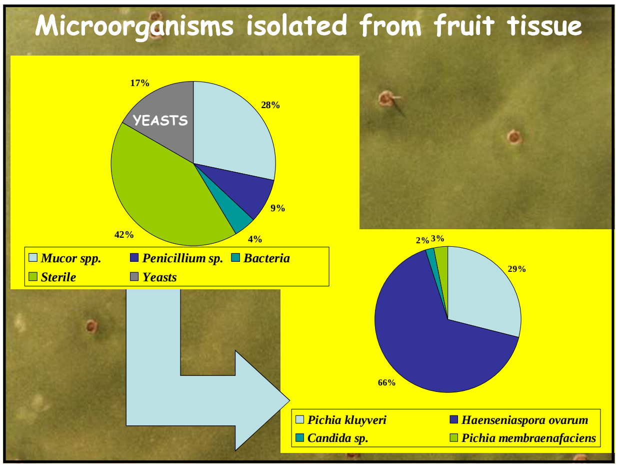
- Proof of true pathogenic ability often lacking.
- Usually involve secondary pathogens due to predisposition by abiotic factors.

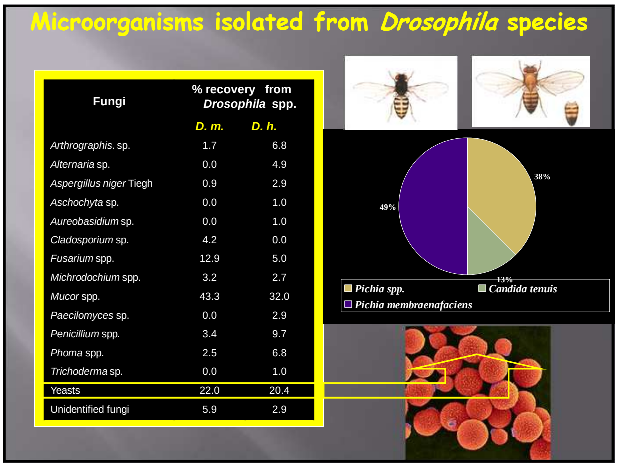
The Cryptic Nature of CP diseases

- Physiology of CP is highly conducive to disease complexes.
- Colonization by fungi and/or bacteria very rapid due to high sugar concentration in cladodes and fruit.
- Symptoms of CP diseases thus difficult to attribute to a specific biotic or abiotic cause.

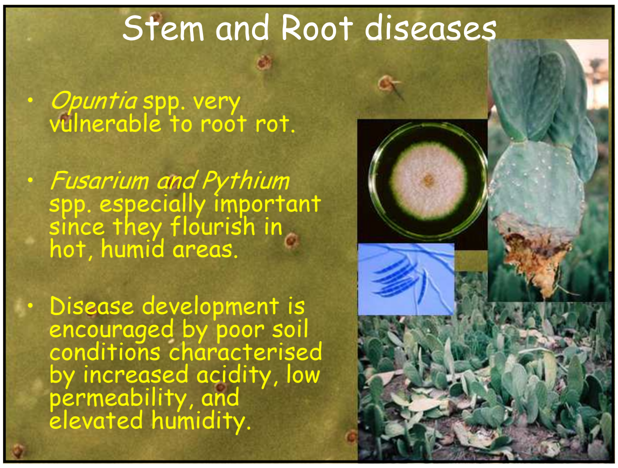








Fungi	% recovery from *Drosophila* spp.	
	D. m.	*D. h.*
Arthrographis. sp.	1.7	6.8
Alternaria sp.	0.0	4.9
Aspergillus niger Tiegh	0.9	2.9
Aschochyta sp.	0.0	1.0
Aureobasidium sp.	0.0	1.0
Cladosporium sp.	4.2	0.0
Fusarium spp.	12.9	5.0
Michrodochium spp.	3.2	2.7
Mucor spp.	43.3	32.0
Paecilomyces sp.	0.0	2.9
Penicillium spp.	3.4	9.7
Phoma spp.	2.5	6.8
Trichoderma sp.	0.0	1.0
Yeasts	22.0	20.4
Unidentified fungi	5.9	2.9



Stem and Root Diseases

Argentina & Italy
- *Armillaria mellea*

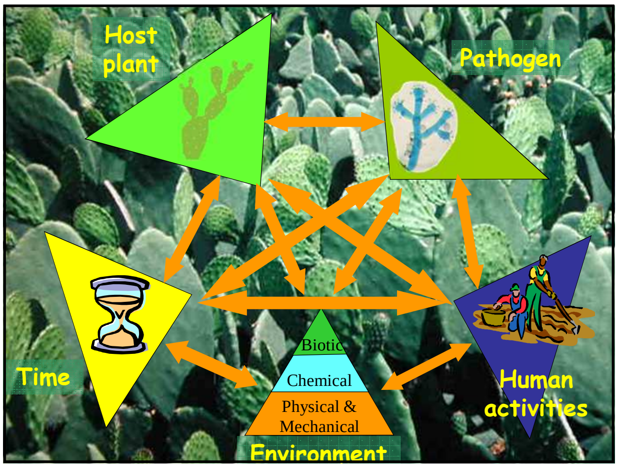
Mexico
- *Fusarium solani*
- *Fusarium oxysporum*
- *Agrobacterium tumefaciens*

USA
- *Fusarium cactorum*
- *Pythium aphanidermatum*
- *Phytophthora nicotianae*

South Africa
- *Fusarium proliferatum*
- *Fusarium solani*
- *Fusarium oxysporum*

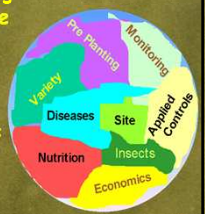
MANAGING CACTUS PEAR DISEASES
The Role of the Environment

BIOTIC (living)	ABIOTIC (non-infectious)	
BIOLOGICAL	CHEMICAL	PHYSICAL
Infectious agents:	Soil acidity / alkalinity	Compacted soil
Fungi	Air pollution	Day length
Bacteria	Mineral toxicities	Drought
Viruses / viroids	Growth hormones	Water logging
Phytoplasmas	Nutrient deficiencies	Fire
Parasitic plants	Pesticides	Frost
Nematodes	Soil salinity	Heat stress
Protozoa		Lightning
Non-infectious agents:		Light intensity
Insects		UV radiation
Mammals		Wind
Mites		
Birds		
Slugs, snails		
Weeds		



MANAGING CACTUS PEAR DISEASES
Understanding and Decoding Interactions

- Knowledge of the role of abiotic factors in predisposing single cactus pear plants to infection, or in exacerbating disease severity in a population of plants, is vague.
- Better understanding of biotic/abiotic interactions crucial for formulation of a long-term, sustainable disease management strategy.
- Holistic approach to diagnosis and disease management is thus imperative!

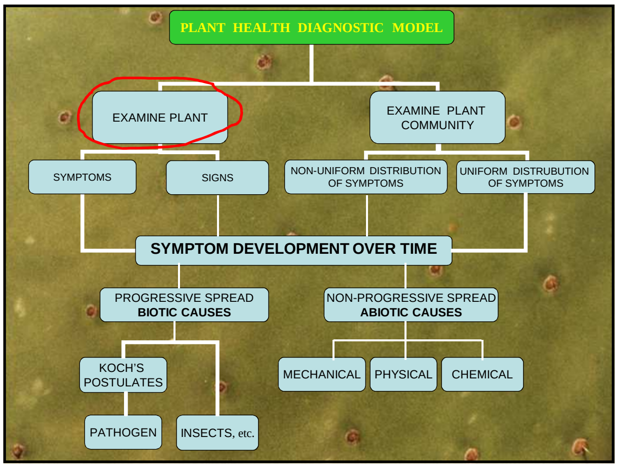


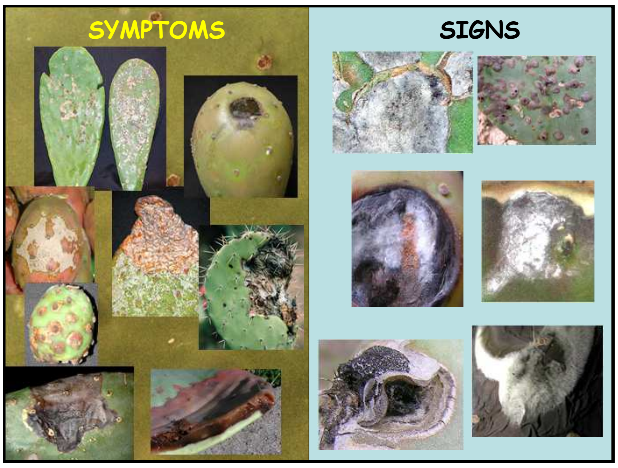
MANAGING CACTUS PEAR DISEASES
The Importance of Accurate Diagnosis

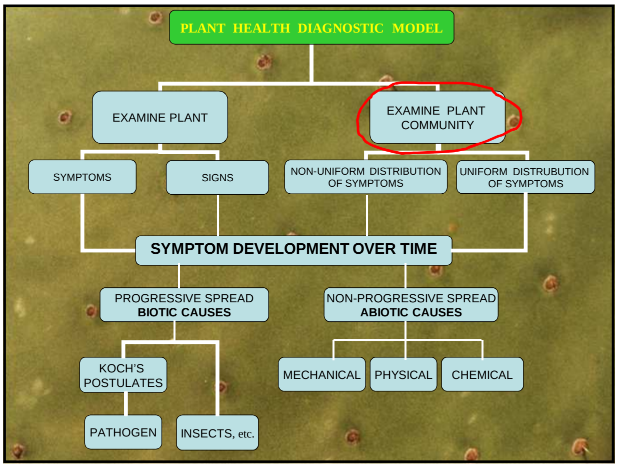
- Misidentification can lead to control failure.
- Different management tactics have different influences on different pathogens.
- Fungicides target only certain pathogens while others remain unscathed.
- Fertilizers may selectively influence pathogens;
  - e.g. some fungal pathogens suppressed by N application while others benefit.

MANAGING CACTUS PEAR DISEASES
Pitfalls of disease diagnosis

- Macro symptoms of different diseases may be similar.
- Symptoms for different pathogens are often the same.
- The same pathogen may cause many different symptoms.
- Pathogens may look the same but cause different symptoms.


PLANT HEALTH DIAGNOSTIC MODEL
EXAMINE PLANT
EXAMINE PLANT COMMUNITY
SYMPTOMS
SIGNS
NON-UNIFORM DISTRIBUTION OF SYMPTOMS
UNIFORM DISTRUBUTION OF SYMPTOMS
SYMPTOM DEVELOPMENT OVER TIME
PROGRESSIVE SPREAD BIOTIC CAUSES
NON-PROGRESSIVE SPREAD ABIOTIC CAUSES
KOCH'S POSTULATES
PATHOGEN
INSECTS, etc.
MECHANICAL
PHYSICAL
CHEMICAL


SYMPTOMS
SIGNS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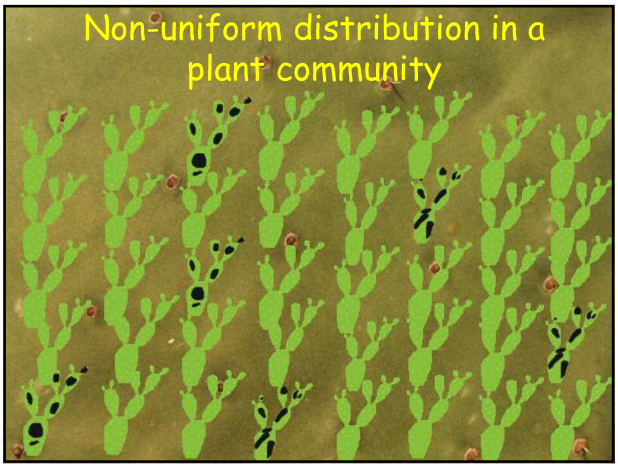
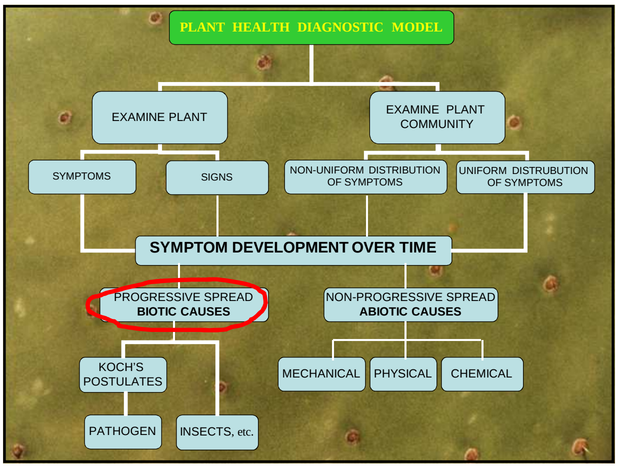
MECHANICAL
PHYSICAL
CHEMICAL


Uniform distribution in plant community


Non-uniform distribution in a plant community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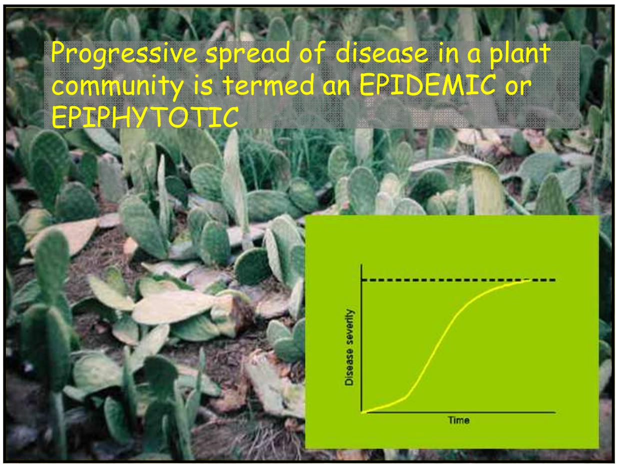
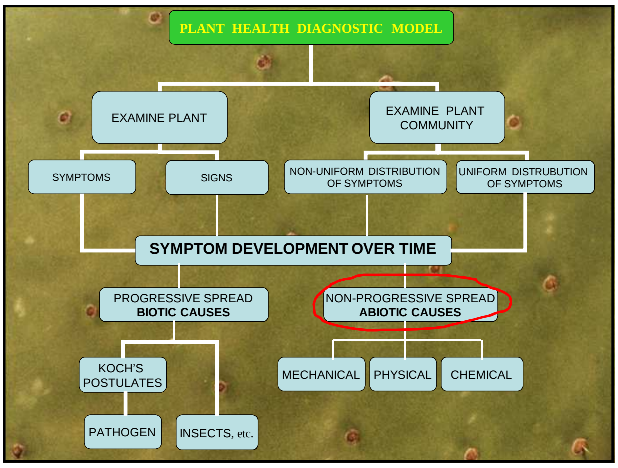
KOCH'S POSTULATES
PATHOGEN
INSECTS, etc.
MECHANICAL
PHYSICAL
CHEMICAL


PROGRESSIVE SPREAD IN A SINGLE PLANT
BIOLOGICAL
Infectious agents:
Fungi
Bacteria
Viruses / viroids
Phytoplasmas
Parasitic plants
Nematodes
Protozoa
Non-infectious agents:
Insects
Mammals
Mites
Birds
Slugs, snails
Weeds


Progressive spread in a plant community


Progressive spread of disease in a plant community is termed an EPIDEMIC or EPIPHYTOTIC
Disease severity
Time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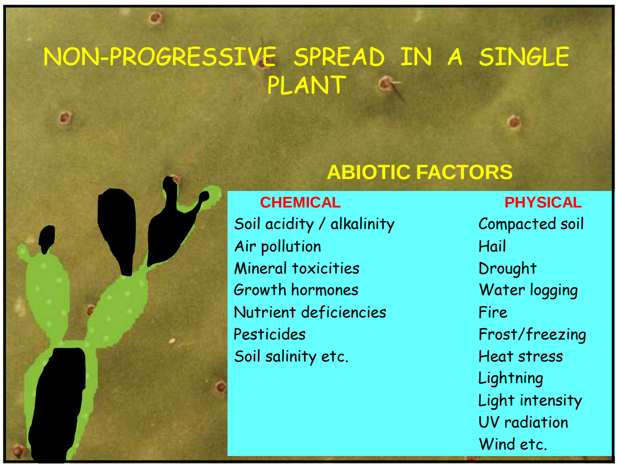
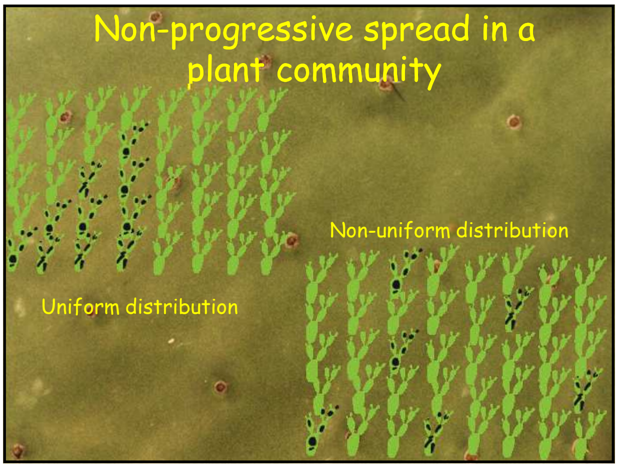
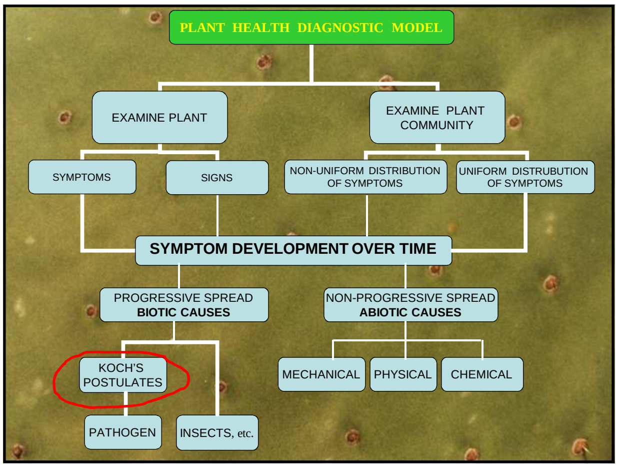

NON-PROGRESSIVE SPREAD IN A SINGLE PLANT
ABIOTIC FACTORS
CHEMICAL
Soil acidity / alkalinity
Air pollution
Mineral toxicities
Growth hormones
Nutrient deficiencies
Pesticides
Soil salinity etc.
PHYSICAL
Compacted soil
Hail
Drought
Water logging
Fire
Frost/freezing
Heat stress
Lightning
Light intensity
UV radiation
Wind etc.


Abiotic agents
• Freezing, hail and sun-scald can cause similar symptoms to biotic agents.
Sun damage
Hail damage
Freezing damage





MANAGING CACTUS PEAR DISEASES
Koch's postulates

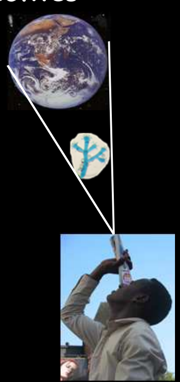
1. Suspected pathogen must be consistently associated with same symptoms.
2. Suspected pathogen must then be isolated and grown in pure culture on nutrient agar away from host and its characteristics described.
3. Organism from pure culture must be re-inoculated into a healthy host plant of same species.
4. Symptoms identical to original disease should then develop.
5. Organism should then be re-isolated from test host to pure culture and must be identical with organism initially isolated.

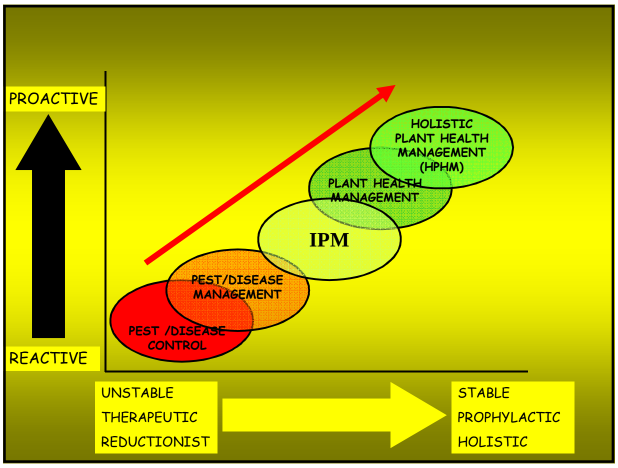
MANAGING CACTUS PEAR DISEASES
The "Total System Approach"

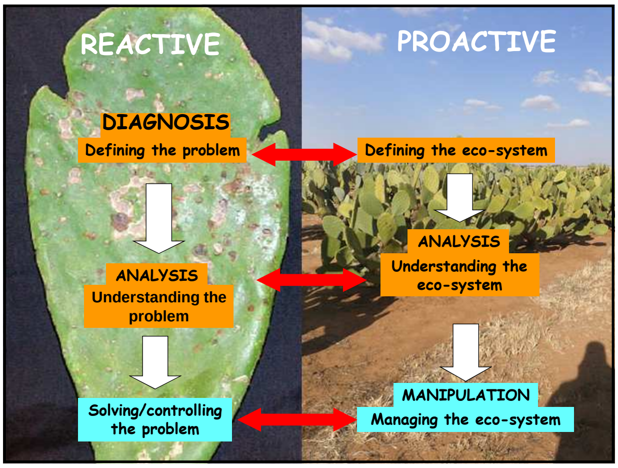
- Should a pathogenic organism be convincingly associated with specific symptoms it is necessary to ask questions such as:
  - Why is the organism causing damage?
  - How did organism arrive in the system?
  - Why did it establish in the system?
  - How is it disseminated in the system?
  - What natural/biological controls exist in system?

MANAGING CACTUS PEAR DISEASES
New Perspectives

- Answers to be found by "looking beyond" the pest or pathogen.
- This is where the reactive/diagnostic approach becomes more proactive.







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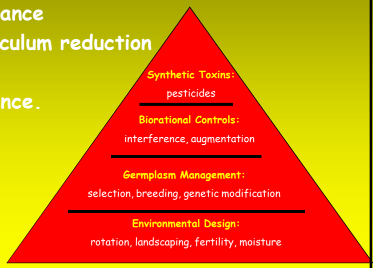
"Prevention is better than cure"

Prevention implies:

1. Exclusion/avoidance
2. Eradication/inoculum reduction
3. Protection
4. Genetic resistance.



1. Exclusion/avoidance

- Best proactive approach is strict phytosanitary regulation.
- Quarantines and pathogen-free certification programmes should be based on sound ecological principles and properly implemented in order to be effective.
- Avoidance of areas where specific cactus pear diseases are known to occur.
- Practices aimed at excluding pathogens/inoculum which promote or facilitate onset of disease in orchards.

2. Eradication/inoculum reduction (1):

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- Inoculum includes spores, mycelium, cells, sclerotia and other structures whereby pathogens survive and are dispersed by rain, wind or insects.

- Destruction of diseased material removes inoculum & limits disease incidence and severity in cactus pear orchards.
- Methods for eradicating inoculum include pruning, sanitation, crop rotation, soil fumigation, trap crops, etc.
- Regular inspection of orchards necessary to determine the presence of diseases so that inoculum can be eliminated.

2. Eradication/inoculum reduction (2):

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- Cactus pear diseases are often exacerbated by insects attracted to sweet sticky exudations of rotting fruit.
- There are numerous reports of insects such as flies acting as vectors for micro-organisms that can cause disease in *Opuntia* sp.
- The families Syrphidae, Otitidae and Ephydridae have been shown to be vectors of *Erwinia carotovora* subsp. *carotovora* the causal agent of cladode soft rot.

2. Eradication/inoculum reduction (3):

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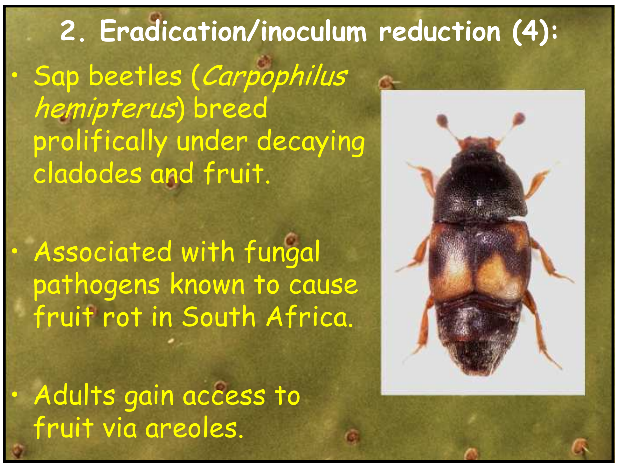
- **We identified at least 13 genera of mycelial fungi from two species of vinegar flies.**
- **Commonly found on fallen fruit in cactus pear orchards.**
- **Larvae and adults feed on fungi and bacteria in decaying cactus pear fruit.**

Drosophila spp.

Soft rot


2. Eradication/inoculum reduction (4):
Sap beetles (Carpophilus hemipterus) breed prolifically under decaying cladodes and fruit.
Associated with fungal pathogens known to cause fruit rot in South Africa.
Adults gain access to fruit via areoles.


3. Protection
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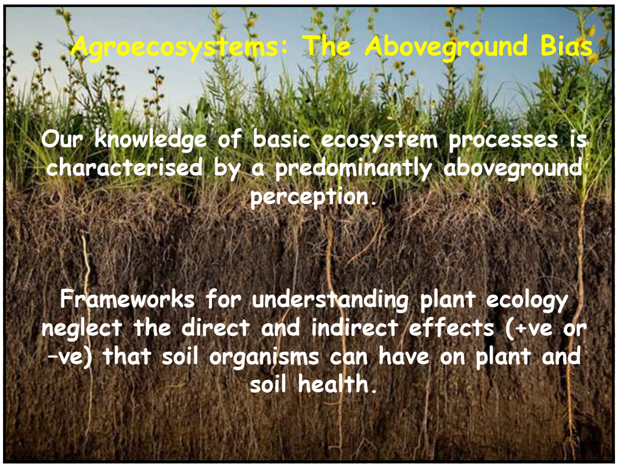
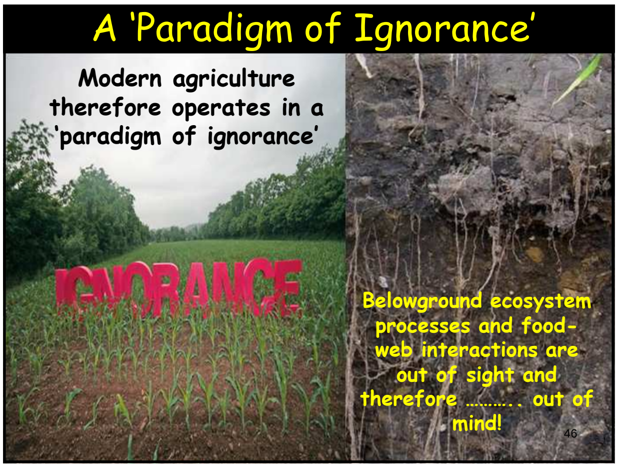
Direct approach:
Reactive
Physical and chemical control
Entails application of synthetic fungicides, bactericides, insecticides, miticides, nematicides or plant extracts.
Indirect approach:
Proactive
Biological control
Based on ecological principles that allow for a strategy that is environmentally friendly and sustainable.


Agroecosystems: The Aboveground Bias
Our knowledge of basic ecosystem processes is characterised by a predominantly aboveground perception.
Frameworks for understanding plant ecology neglect the direct and indirect effects (+ve or -ve) that soil organisms can have on plant and soil health.


A 'Paradigm of Ignorance'
Modern agriculture therefore operates in a 'paradigm of ignorance'
IGNORANCE
Belowground ecosystem processes and food-web interactions are out of sight and therefore ……….. out of mind!
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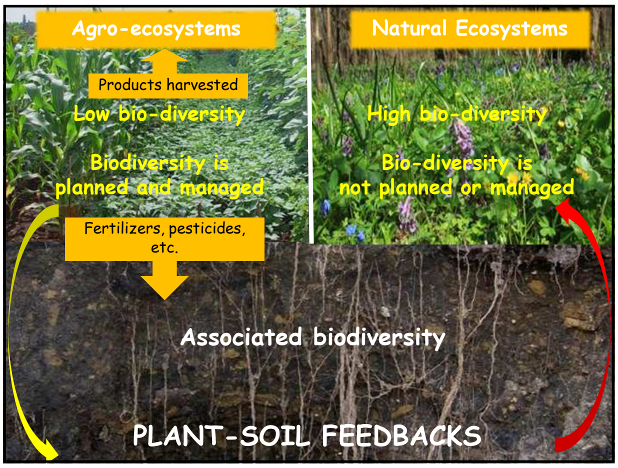
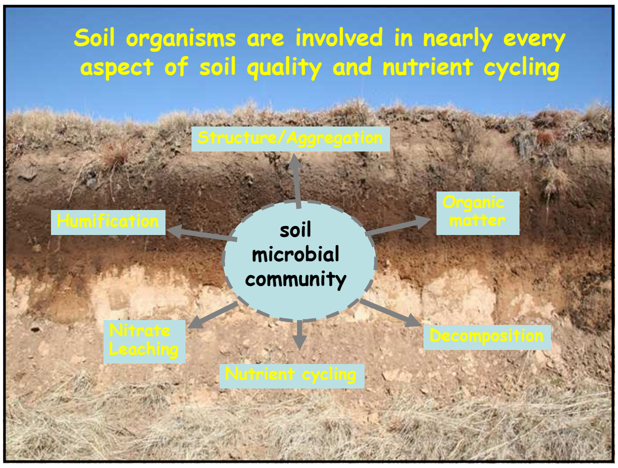
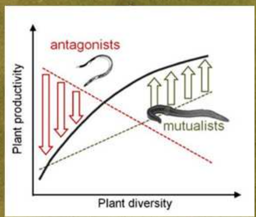

Agro-ecosystems
Products harvested
Low bio-diversity
Biodiversity is planned and managed
Fertilizers, pesticides, etc.
Natural Ecosystems
High bio-diversity
Bio-diversity is not planned or managed
Associated biodiversity
PLANT-SOIL FEEDBACKS


Soil organisms are involved in nearly every aspect of soil quality and nutrient cycling
Structure/Aggregation
Humification
Organic matter
soil microbial community
Nitrate Leaching
Nutrient cycling
Decomposition

Biological Control: The Diversity-Productivity Relationship

Antagonists (pathogens & herbivores) decrease the productivity of species-poor plant communities.

Mutualists (mycorrhizal fungi, rhizobia, decomposers and plant growth promoting rhizobacteria) may increase productivity of species-rich communities.



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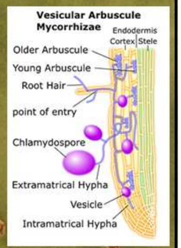
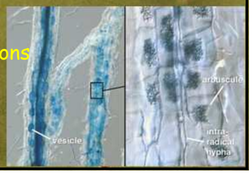
Eisenhauer, Plant & Soil, 2012. 351: 1-22

Mycorrhizae

- Myco = fungus rhiza = root
- More than 90% of plants have mycorrhizal relationships.
- Growth of arbuscular mycorrhizal fungi (AMF) is enhanced in such patches and mycorrhizal potential has been shown to increase in the rhizosphere of arid plant species.
- Under harsh environmental conditions AMF plants in patches display:
  - increased competitive ability
  - stimulated growth
  - increased drought resistance





Mycorrhiza-Induced Plant Defence

Non-mycorrhizal plant (– AMF)	Mycorrhizal plant (+AMF)
• Increased disease damage • Increased insect damage • Feeding damage in roots & shoots	• Growth promotion • Repel nematodes and herbivores • Attract antagonists & predators. • Prime plant defences

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Cactus pear: The Extra-terrestrial Connection

- *Opuntia ficus-indica* was chosen as a possible starter plant for an ET colony because it establishes itself easily and is one of the most productive crop plants known.
- The lunar regolith simulant JSC-1A is a volcanic, nutrient-poor and dusty soil that simulates the soil retrieved from the moon by NASA and was used to study the suitability of plants for agriculture in a lunar colony.

Advances in Microbiology, 2014, 4, 616-626
Published Online August 2014 in SciRes. http://www.scirp.org/journal/aim
http://dx.doi.org/10.4236/aim.2014.410068

Scientific Research

Endomycorrhizal Fungi and *Opuntia ficus-indica* Seed Germination on a Lunar Regolith Simulant

Gertrud Konings-Dudin*, Michelle J. Butcher, Jesus A. Castor-Macías, Benjamin Kohanloo, Michelle Garcia

Cactus pear: The Extra-terrestrial Connection

- The mycorrhizal fungus *Trichoderma viride* was predominantly identified on the roots of new seedlings and had the strongest effect on the germination rate of the seeds in comparison with other fungi isolated from the rhizosphere of *Opuntia* plants.
- *T. viride* was not detected within seeds and also not within seedlings, besides the root tips.
- The arbuscular mycorrhizal fungus *Glomus* sp. was seed-borne and present throughout most of the seedling.
- A close association occurred between *T. viride* and the Glomus sp. on *O. ficus-indica* roots.

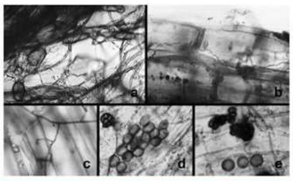


Figure 4. Mycorrhizae on roots of seedlings: septate hyphae of *T. viride* grow alongside the coenocytic *Glomus* hyphae outside of the root (a); Septate hyphae show penetration into the root (c). Vesicles formed by the AM fungus are visible (b) (d) (e); and on the root sporangia at the end of septate hyphae resemble those of *T. viride* (d) & (e) (Magnification 1000×).

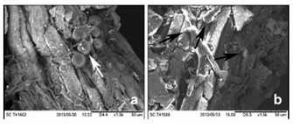
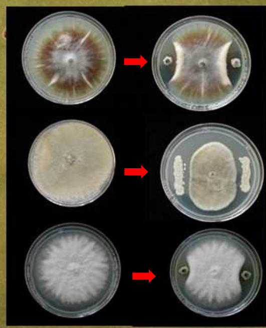


Figure 5. (a) Spores of the AM fungus on the root of a seedling (white arrow); (b) Penetration of the hyphae into the root cells are indicated by black arrows (SEM magnification 1500×).

Post-harvest Biological control



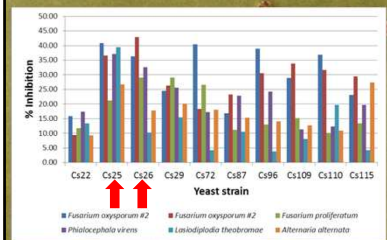
Yeast isolates with antifungal activity *in vitro*

Aim: To identify yeasts with biocontrol activity against cactus pear pathogens.

Over 270 strains isolated from the surface of cactus pear fruit were screened *in vitro* in dual culture tests.

Ten strains were selected for further *in vitro* evaluation on nutrient agar against six pathogens of cactus pear.

Post-harvest biological control



All strains significantly (P ≤ 0.05) reduced colony diameter of the six pathogens, except for L. theobromae.

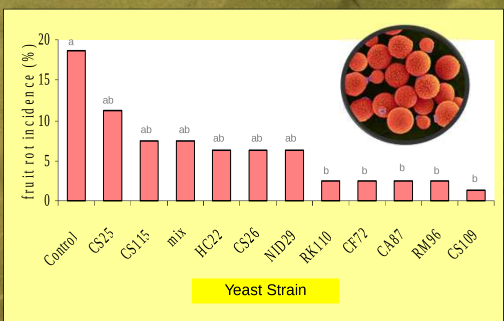
Seven days after incubation, colonies of most of the pathogens exposed to *Cryptococcus saitoi* (CS25) did not grow more than 50 mm in diameter while the colony diameters of yeast-free cultures were 80-100 mm.

Averaged over all pathogens, the highest inhibition of mycelial growth (35%) was obtained with *C. saitoi* (CS25) followed by *C. saitoi* (CS26) (28%).

Post-harvest biological control

- Ten yeast isolates which showed antifungal activity *in vitro* were tested for their effect on fruit rot on fruit ready for commercial packaging (brushed and washed).
- Yeast inoculum was prepared from 48 hr old cultures. Concentration adjusted to ~ 1 x 10^9 cells/ml.
- Fruits dipped in suspension for 30 sec and placed in carton used for commercial packaging.
- After 10 days in storage, all strains resulted in significantly lower incidence of fruit rot than the control treatment.
- Species of *Fusarium, Alternaria and Rhizopus* were isolated from rotting fruit.

Incidence of fruit rot after 10 days storage following treatment with 10 yeast isolates



4. Genetic resistance.

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- Selective breeding for resistance to diseases is probably the best means of preventing plant disease
- Genotypic characterization of cactus pear cultivars can greatly facilitate such breeding strategies.
- The identification and exploitation of differences aided by biotechnological techniques such as AFLP-fingerprinting provides valuable information for parental selection.
- Valuable contributions made by Masters study of Rae Oelofse in 2002 and Ph.D. study of Dr Barbara Moshope in 2007 on AFLP fingerprinting of cactus pear germplasm in South Africa.

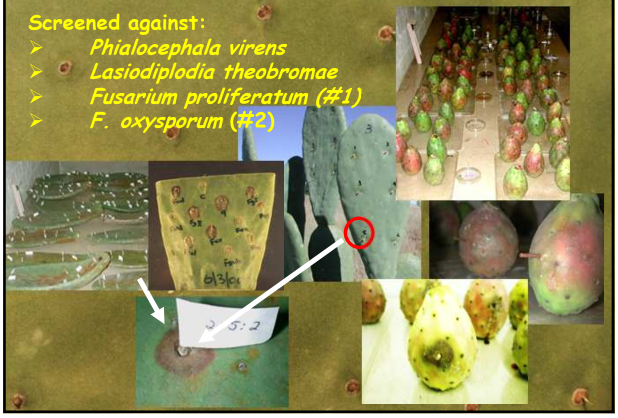
Oelofse, R.M. 2002. Characterization of *Opuntia ficus-indica* cultivars in South Africa. M.Sc. Agric. dissertation. UFS, Bloemfontein, South Africa.

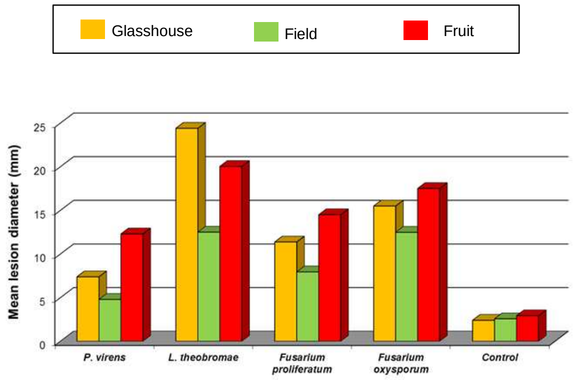
- Plant material of 10 varieties was characterised based on:
  - General horticultural characteristics
  - characteristics for use as fodder
  - Susceptibility to four fungal pathogens
- Varieties were genetically characterised using AFLP markers.
- Morphological data were compared with genetic data

Disease Susceptibilty of *Opuntia* varieties

Screened against:

- *Phialocephala virens*
- *Lasiodiplodia theobromae*
- *Fusarium proliferatum (#1)*
- *F. oxysporum (#2)*



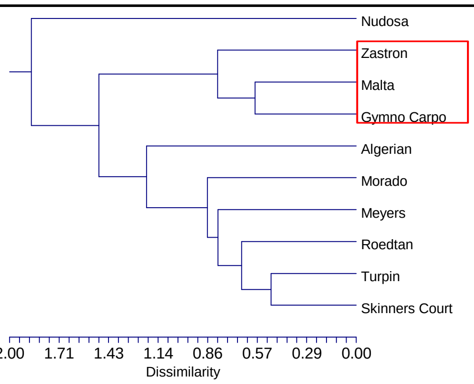


Mean lesion diameters on cladodes following artificial inoculations of cladodes in the glasshouse and field and fruit in the laboratory

Cladodes GH		Fruit		Cladodes Field	
Zastron	9.14	Gymno Carpo	8.3	Zastron	5.665
Gymno Carpo	11.91	Zastron	8.33	Gymno Carpo	6.335
Skinners Court	13.58	Malta	8.51	Malta	6.45
Turpin	14	Turpin	16.22	Turpin	8.753
Morado	14.42	Skinners Court	17.12	Morado	9.305
Malta	14.55	Roedtan	17.21	Skinners Court	9.665
Roedtan	14.97	Morado	18.96	Roedtan	10.68
Meyers	15.07	Meyers	19.42	Meyers	11.88
Algerian	16.42	Nudosa	22.72	Nudosa	12.6
Nudosa	24.8	Algerian	23.99	Algerian	12.9

Mean lesion diameter (mm)

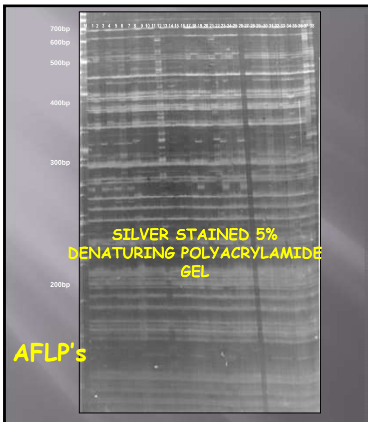
Ranking of cv's following artificial inoculations of cladodes (glasshouse & field) and fruit (laboratory)



Dendogram generated by UPGMA analysis of the combined data collected from inoculation trials of cladodes (glasshouse and field) and fruit (laboratory).

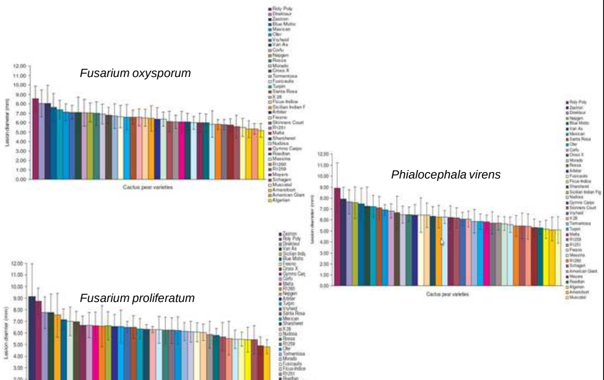
Mashope, B.K. 2007. Characterization of cactus pear germplasm in South Africa. PhD thesis, UFS, Bloemfontein, South Africa.

- Genetically fingerprint germplasm of 38 varieties of *O. ficus-indica* using AFLP markers.
- Varieties were evaluated for disease resistance, cladode nutritional quality and fruit quality.
- In addition, a search to find yeasts able to limit post-harvest rot of fruit was undertaken.



Mashope, B.K. 2007. Characterization of cactus pear germplasm in South Africa. PhD thesis, UFS, Bloemfontein, South Africa.

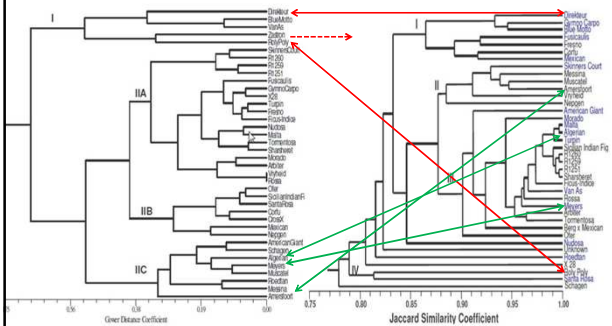
Lane	Description
M	100 bp DNA Ladder
1	DIREKTEUR
2	SKINNERS COURT
3	FUSICAULIS
4	NUDOSA
5	GYMNO CARPO
6	AMERICAN GIANT
7	BLUE MOTTO
8	MORADO
9	MALTA
10	ALGERIAN
11	TURPIN
12	ROLY POLY
13	MEYERS
14	ROEDTAN
15	ARBITER
16	OFER
17	MESSINA
18	FRESNO
19	MUSCATEL
20	TORMENTOSA
21	X 28 (ROBUSTA x CASTILLO)
22	CORFU
23	FICUS-INDICA
24	VRYHEID
25	MEXICAN
26	NEPGEN
27	AMERSFOORT
28	SICILIAN INDIAN FIG
29	R 1260
30	R 1259
31	R 1251
32	SHARSHERET
33	ROSSA
34	Unknown
35	VAN AS
36	BERG x MEXICAN
37	SANTA ROSA
38	SCHAGEN



Mashope, B.K. 2007. Characterization of cactus pear germplasm in South Africa. PhD thesis, UFS, Bloemfontein, South Africa.

Dendrogram of 38 CP varieties constructed on the basis of overall susceptibility to 3 fungal pathogens. The Gower dissimilarity coefficient was used to estimate dissimilarity between varieties.

Dendrogram of 38 South African CP varieties based on cluster analysis (UPGMA) of genetic similarity estimates (AFLP markers) using the Jaccard similarity coefficient. (Varieties in blue are those cultivated for fruit in SA).



Most susceptible (Direkteur, Zastron, Roly Poly)

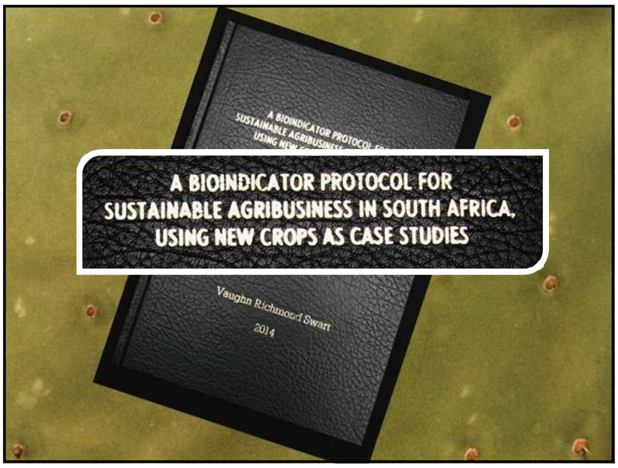
Most resistant (Amersfoort, Meyers, Algerian)

Summary of Mashope's research

- AFLP fingerprinting data revealed distinct differences between the accessions currently cultivated in South Africa.
- The expression of disease resistance within the varieties surveyed indicates a quantitative mode of resistance across all varieties evaluated for all three pathogens tested.
- Roly Poly, Direkteur, and Zastron were the most susceptible varieties.
- The most resistant varieties were Amersfoort, Meyers, and Algerian.
- Mashope's results inconsistent with Oelofse's 2002 results where Zastron was most resistant and Algerian most susceptible to the same three pathogens.
- Inconsistency could be attributed to differences in climatic conditions prevailing during field trials, as the amount and occurrence of infection can be influenced by environmental conditions that influence the host and pathogen (i.e. GxE).

TO WRAP UP……………

- Different ecological principles and management practices apply to the cultivation of new crops such as cactus pear. An integrated and holistic approach is thus important for the management of pests and diseases on the crop.
- Our research over the past 15 years has revealed numerous interactions between insects such as *Drosophila* species & pathogenic fungi of *Opuntia ficus-indica* that were previously unknown.
- Similarly, new interactions between various fungal and bacterial pathogens and mutualists such as mycorrhizae associated with the crop have been discovered.
- It is crucial that all these interactions are taken into consideration within the context of a holistic plant health management strategy for cactus pear cultivation.



UFS Publications re: Cactus pear diseases

1. Swart WJ and W-M. Kriel. 2002. Pathogens Associated with Necrosis of Cactus Pear Cladodes in S. Africa. Plant Disease 86: 693
2. Swart, W.J. & Swart, V.R. 2002. The current status of research on diseases of *Opuntia ficus-indica* in South Africa. Acta Horticulturae 581: 239-245.
3. Swart, W.J., Oelofse, R.M. & Labuschagne, M.T. 2003. Susceptibility of South African cactus pear varieties to four fungi commonly associated with disease symptoms. *Jnl of the Professional Association for Cactus Development* 5: 86-97.
4. Swart, W.J. & Swart, V.R. 2003. An overview of research on diseases of cactus pear in South Africa. *Journal of the Professional Association for Cactus Development* 5: 115-120.
5. Swart, W.J. 2009. Strategies for the management of cactus pear diseases: A global perspective. *Acta Horticulturae* (ISHS) 811:207-216.
6. Louw, S. Parau, J.V. and Olevano, J.C. 2009. Bio-Ecology of Sap Beetles (Nitidulidae), a New Double Impact Pest on Cactus Pear in South Africa. . Acta Horticulturae (ISHS) 811:217-221.

UFS Congress Presentations re: Cactus pear diseases

1. Swart, V.R., Swart, W.J., Louw, S.VdM. & Kriel, W-M. 2003. Relationships between potentially phytopathogenic fungi and insect phytophages associated with cactus pear, pistachio and pigeon-pea in South Africa. 41st Annual Plant Pathology Congress, SASPP, Bain's Game Lodge, Bloemfontein, South Africa. 19-22 January. SA Journal of Science 99: ix
2. Swart, W.J. & Swart, V.R. 2004. Pests and diseases of cactus pear in South Africa. Fourth Symposium of the Southern African New Crop Research Association, ARC-Infruitec, Stellenbosch, South Africa. 6-8 September.
3. Swart, V.R., Swart, W.J., Louw, S.VdM. & Kriel, W-M. 2000. An ecological complex of parasitic fungi associated with Drosophila spp. that utilize Opuntia ficus-indica in South Africa. IVth International Congress on Cactus Pear and Cochineal, Hammamet, Tunisia. 22-28 October.
4. Swart, W.J., Amadi, J.E. & Viljoen, B.C. 2000. The current status of research on diseases of Opuntia ficus-indica in South Africa. IVth International Congress on Cactus Pear and Cochineal, Hammamet, Tunisia. 22-28 October.
5. Swart, W.J. 2006. Holistic health management in cactus pear orchards in South Africa. Proceedings of the 2006 International Cactus Pear Congress, University of the Free State, Bloemfontein, South Africa. 29-31 March. p. 8.
6. Tarekegn, G., Mashope, B.K. & Swart, W.J. 2006. Biological control of cactus pear pathogens using yeasts. Proceedings of the 2006 International Cactus Pear Congress, UFS, Bloemfontein, South Africa. 29-31 March. p. 10.
7. Swart, W.J. & Louw, S.VdM. 2006. A diagnostic procedure for identifying cactus pear pests and diseases. Proceedings of the 2006 International Cactus Pear Congress, UFS, Bloemfontein, South Africa. 29-31 March. p. 11.
8. Swart, V.R., Swart, W.J. & Louw, S.VdM. 2006. Ecological aspects of fungal pathogens and Drosophila spp. Proceedings of the 2006 International Cactus Pear Congress, UFS, Bloemfontein, South Africa. 29-31 March. p. 12.
9. Tesfaendrias, M.T., Tarekegn, G. & Swart, W.J. 2006. The pathogenicity of fungi isolated from cactus pears. Proceedings of the 2006 International Cactus Pear Congress, University of the Free State, Bloemfontein, South Africa. 29-31 March. p. 13.
10. Swart, W.J. 2007. Strategies for the management of cactus pear diseases: A global perspective. VI International Conference on Cactus Pear and Cochineal and the VI General Meeting of the FAO-CACTUSNET, João-Pessoa, Brazil. 22-26 October. (Invited keynote address)

THANK YOU!

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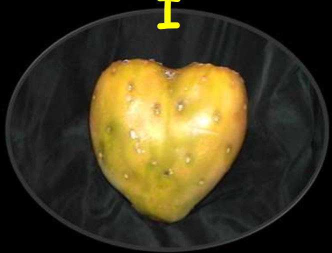

CACTUS PEAR!