Fungal Symbiosis: A Potential Mechanism Of Plant Invasiveness

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Unique habitats
New concepts in plant-fungal symbiosis

Geothermal Soils

Temperature

Coastal Beach

Salinity

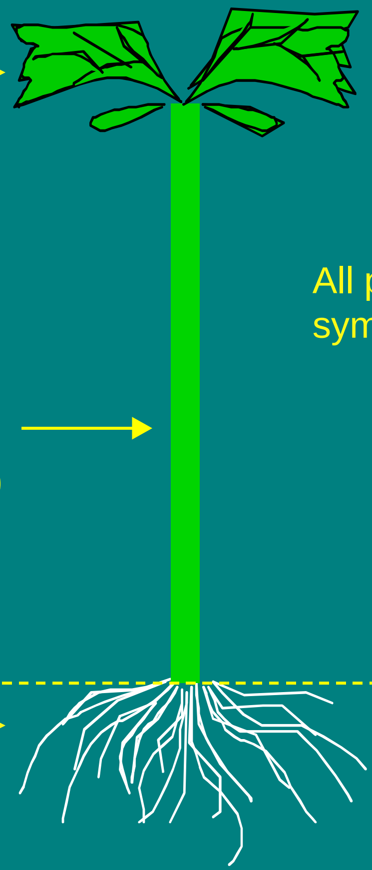
PNW & Utah

Invasive Species

- Adaptive Symbiosis & Symbiotic Modulation

Plants are Communities with Several Habitat Zones

Phyllosphere
(endophytes)
(epiphytes)



All plants in natural ecosystems are symbiotic with endophytic fungi

Plant Matrix
(endophytes)

Rhizosphere
(endophytes)
(mycorrhyzae)

- Fossil records indicate that fungi have been associated with plants for >400 MY
- Symbiosis may be responsible for the movement of plants onto land

(Pirozynski & Malloch, 1975)

Fungal Symbionts

- Mycorrhizae - restricted to roots and grow out into rhizosphere.

•Endophytes - reside entirely within plant; capable of colonizing root, stem, and/or leaf tissues.

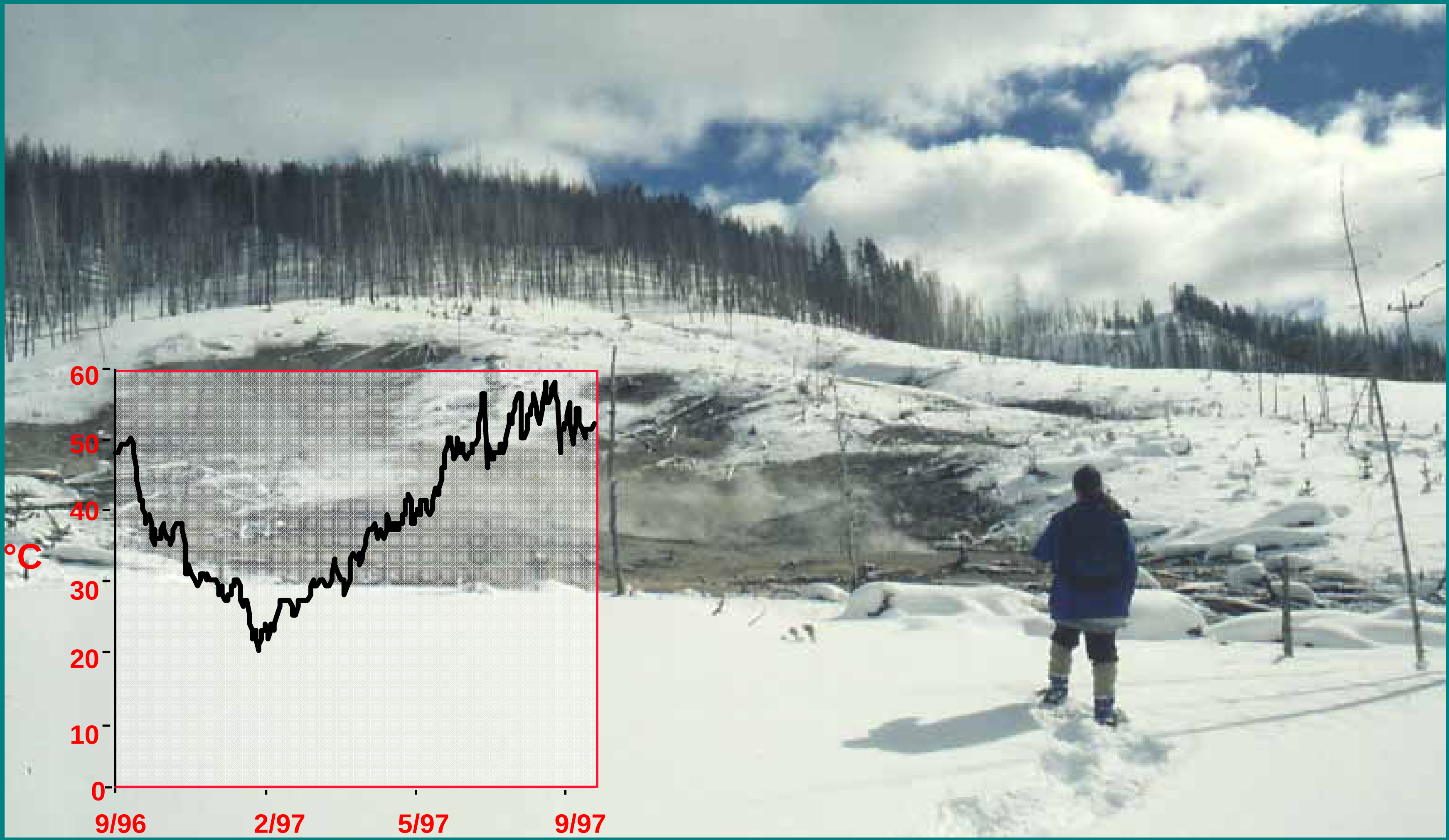
- –Class 1 endophytes: a relatively small number of fastidious species that are limited to a few monocot hosts.
- –Class 2 endophytes: a large number of species with broad host ranges including both monocots and eudicots.

•Has not been well defined

Host Fitness Benefits Conferred by Mutualistic Fungi

- Disease Resistance
- Drought Tolerance
- Metal Tolerance
- Herbivore Resistance
- Growth Enhancement
- Temperature Tolerance

Habitat #1: Geothermal Soils of Amphitheater Springs in Yellowstone National Park



Habitat Specific Stress: High Soil Temperatures

Dichanthelium lanuginosum (Panic Grass) Growing in Hot Geothermal Soils

All plants (N=200) in Yellowstone National Park were colonized with the same fungal endophyte = *Curvularia protuberata.*

Fungus colonized roots, stem, leaves, seed coat but not the seeds.

Does this fungal endophyte isolated from panic grass confer temperature tolerance to plants?

100% live (N=50) 100% dead (N=50)

The root zones of plants temperature cycled at 70°C for 10 hours followed by 14 hours at 37°C for ten days.

Both the plant and the fungus are able to survive symbiotically.

Separately, the plant and fungus are not able to survive temperatures above 38C.

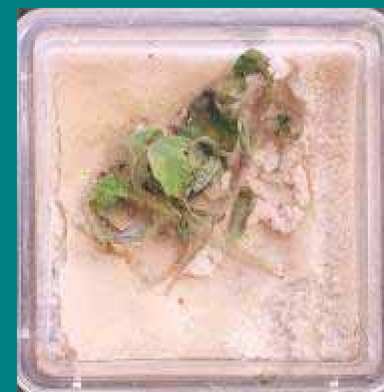
Fungal endophyte imparts temperature tolerance.

Response of Symbiotic and Non-symbiotic Tomato Seedlings to Thermal Stress (50°C, 72hr)

Non-symbiotic

C. magna
Non-thermal
adapted

C. Protuberata
Thermal-adapted



C. Protuberata
Non-thermal
Adapted
ATCC

(N=45)

- Although they are the same species of fungus, functionally different because only the thermal-adapted isolate confers temperature tolerance
- Adaptive Symbiosis = Fungus confers habitat specific stress tolerance

Habitat #2: Cedar Rocks, San Juan Islands, WA

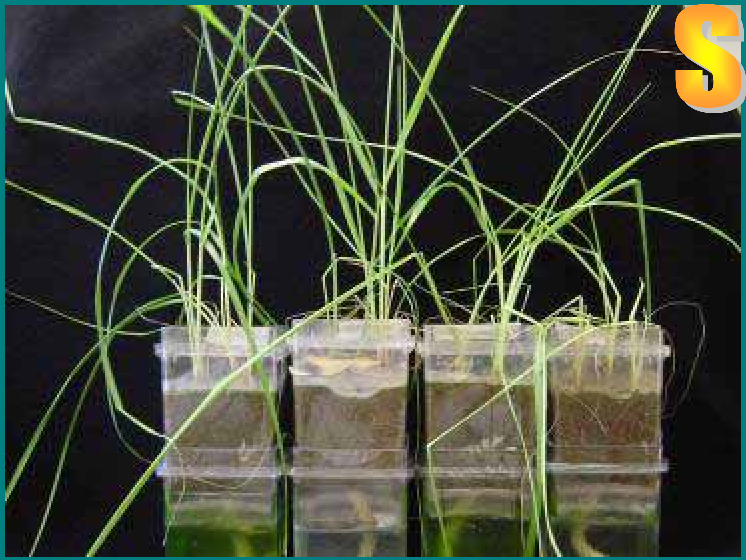
Leymus mollis (Dunegrass) in Beach Habitat

Habitat Specific Stress: High Salinity

All plants (N=100) were found to be colonized with one fungal endophyte species (*Fusarium culmorum)* which we call Red-1

Question: Will this fungal endophyte impart salt tolerance to Dunegrass plants?

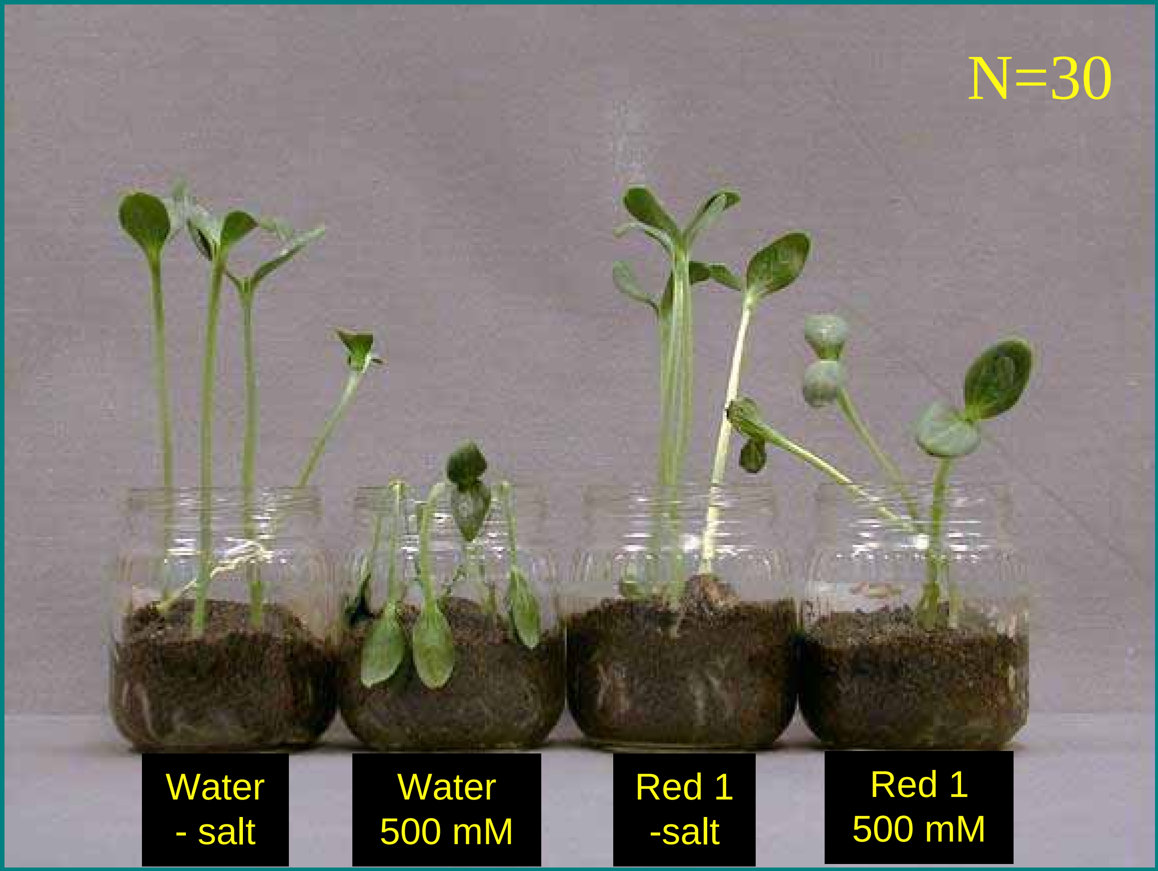
Salinity Tolerance in Dunegrass



- 0 NaCl
- 100mM
- 300mM
- 500 mM

After 3 weeks exposure
(N=60)

Salt Tolerance Conferred to Watermelon by Red 1



Symbiotic communication responsible for stress tolerance appears to be quite old and predates the divergence of monocots and dicots

Mutualistic Benefits vs Stress = Adaptive Symbiosis

Geothermal Soils

Temperature

-

Coastal Beach

-

Salt

Take home message:

•If you can identify the habitat specific stress, you can predict the mutualistic benefit

•Fungi have adapted to confer habitat specific stress tolerance

Dunegrass Endophytes vs. Microhabitat

Symbiotic Modulation:

Plants change endophytes and endophytes change plant hosts in adjacent microhabitats that impose different stresses.

Shaw Island Field Experiment

4 Treatments (N=20), 3 Microhabitats, 2 plantings

Shaw Island Field Results

Beach

Treatment	Survival	Biomass
NS	7/20	10
Red1	**20/20**	**19**
White1	16/20	17
Brown1	12/20	13

Slope

Treatment	Survival	Biomass
NS	20/20	9
Red1	18/20	15
White1	**20/20**	**18**
Brown1	18/20	15

Bluff

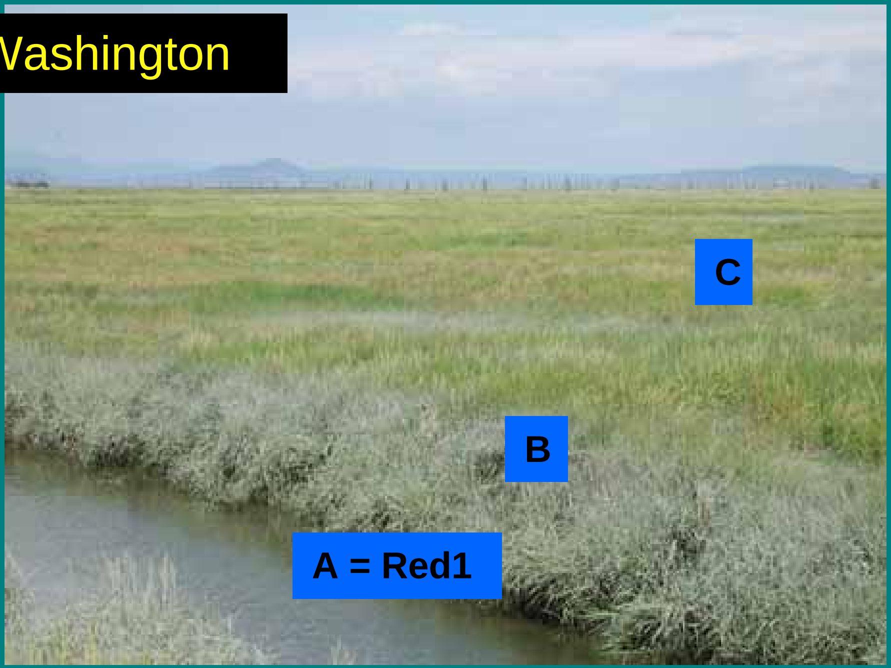
Treatment	Survival	Biomass
NS	11/20	11
Red1	15/20	11
White1	18/20	13
Brown1	**20/20**	**16**

Symbiotic modulation is based on selective pressures imposed at the microhabitat level

Symbiosis of *Spartina anglica* vs. Microhabitat

N=100

Skagit Bay, Washington



-All plants analyzed (N=100) have class 2 fungal endophytes

- Invasive plant has picked-up same endophytes present in native plants

- Distribution of fungal endophytes in non-native species appears to be the same as natives

- Determine the biological and ecological significance of each symbiosis (In progress)

-Are endophytes responsible for plant invasiveness?

Utah Desert Range

Invasive	Native
	
Halogeton glomeratus	*Ceratoides lanata*

	Plant	Endophyte Profile	pH	Conductivity
Zone 1	*Ceratoides*	AB	9.56	52 mS/cm
Zone 2	*Ceratoides*	AB	9.72	86 mS/cm
	Halogeton	ABC		
Zone 3	*Halogeton*	ABC	9.89	98 mS/cm

•Symbiotic Modulation appears to be playing a role in plant invasiveness

Symbionts and Native and Invasive Plants

Native systems:
Endophytes confer adaptive functionality to plants
Endophytes allows plants to adapt to habit & microhabitat stresses

Invasive plant systems:
Symbiotic modulation may play an important role in plant invasiveness.

Invasive plants are picking-up native symbionts which may confer the required functionality to adapt to habitat & microhabitat stresses,

and/or bringing their own unique resident endophytes in combination with the native endophytes which may give the invasive plants a competitive edge.

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