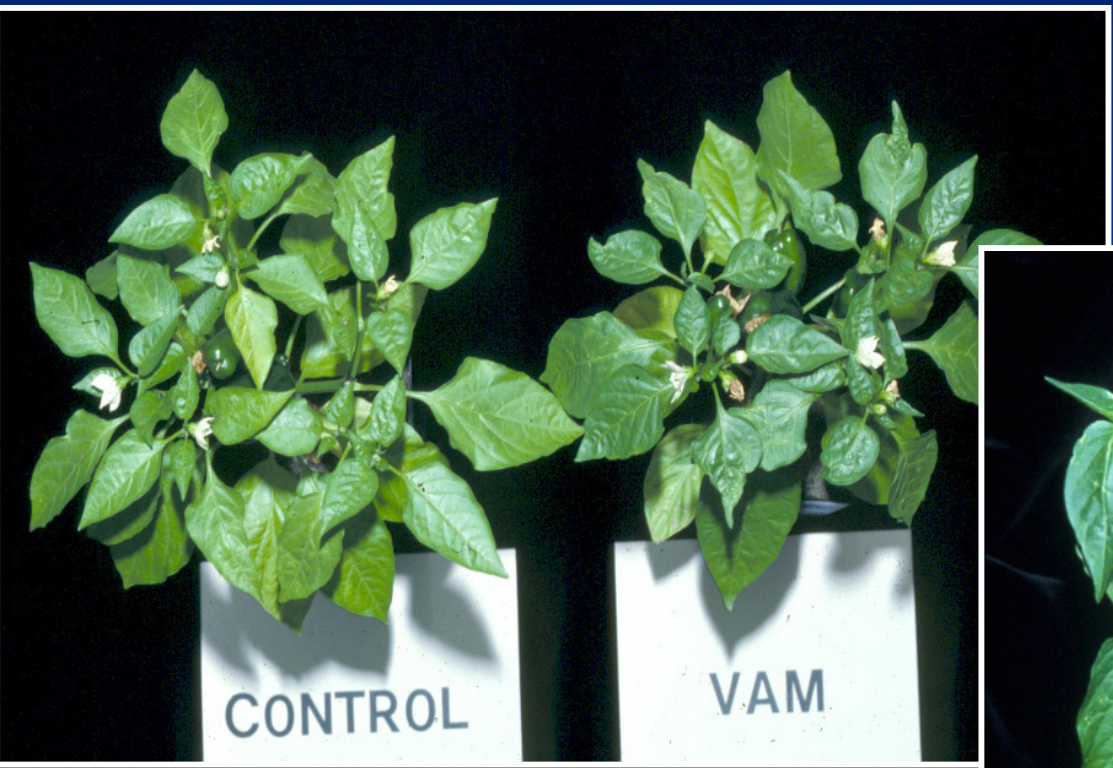
Soil management to conserve water

Mario Lanthier
CropHealth Advising & Research
Kelowna, B.C. www.crophealth.com

Presentation made at
"Xeriscaping for Landscape Professionals"
A workshop by the Okanagan Xeriscape Association
February 26, 2010

This talk: Part 1 - Mycorrhizal fungi
Next talk: Part 2 - Organic matter



Adequate water

20-day water stress

4th International Conference on Mycorrhizae

Montréal, Québec
August 10 – 15, 2003

Quatrième Conférence Internationale sur les Mycorhizes
ICOM4 — 10-15 août 2003

The Fourth International Conference On Mycorrhizae
ICOM4 — August 10-15, 2003

Conjointement avec/jointly with

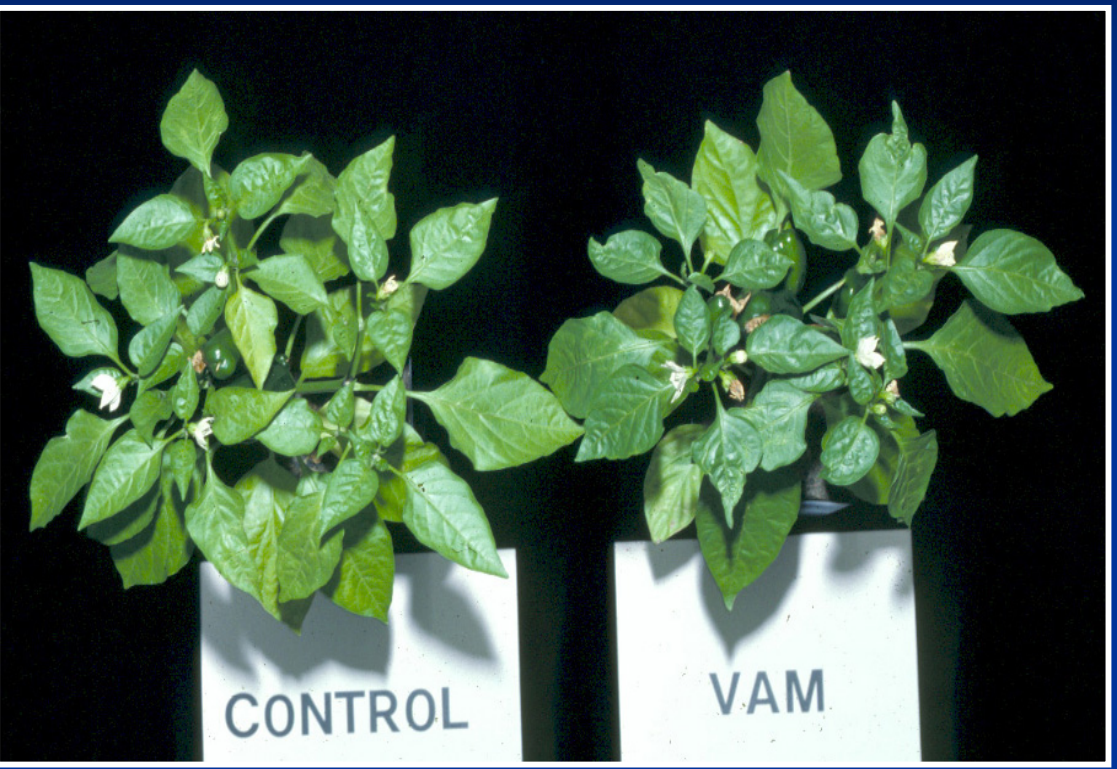
la Société canadienne de Science du Sol (SCSS) et
la Société canadienne d'Agronomie (SCA)
10-13 août 2003

Canadian Society of Soil Science (CSSS) and
Canadian Society of Agronomy (CSA)
August 10-13, 2003

Mycorrhizal fungi and water stress

Pepper plants (*Capsicum a.*) under different water regimes

Pictures from F.T. Davies, Texas A&M University, ICOM 2003

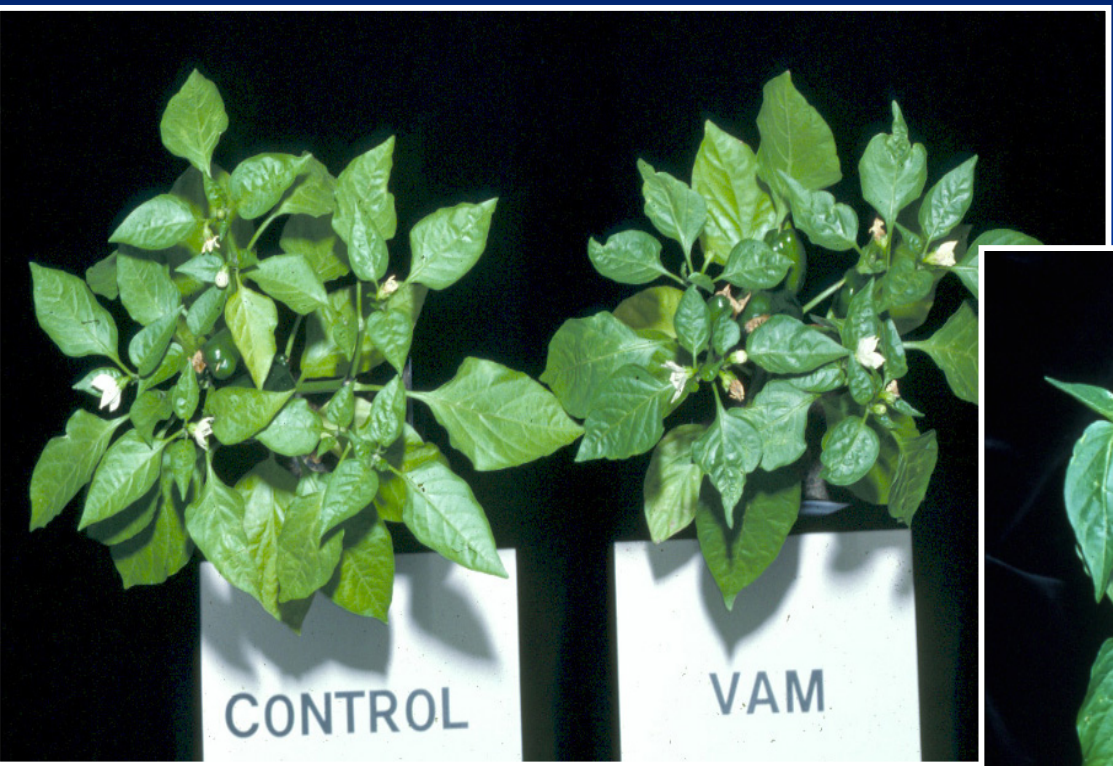


Adequate water

Mycorrhizal fungi and water stress

Pepper plants (*Capsicum a.*) under different water regimes

Pictures from F.T. Davies, Texas A&M University, ICOM 2003



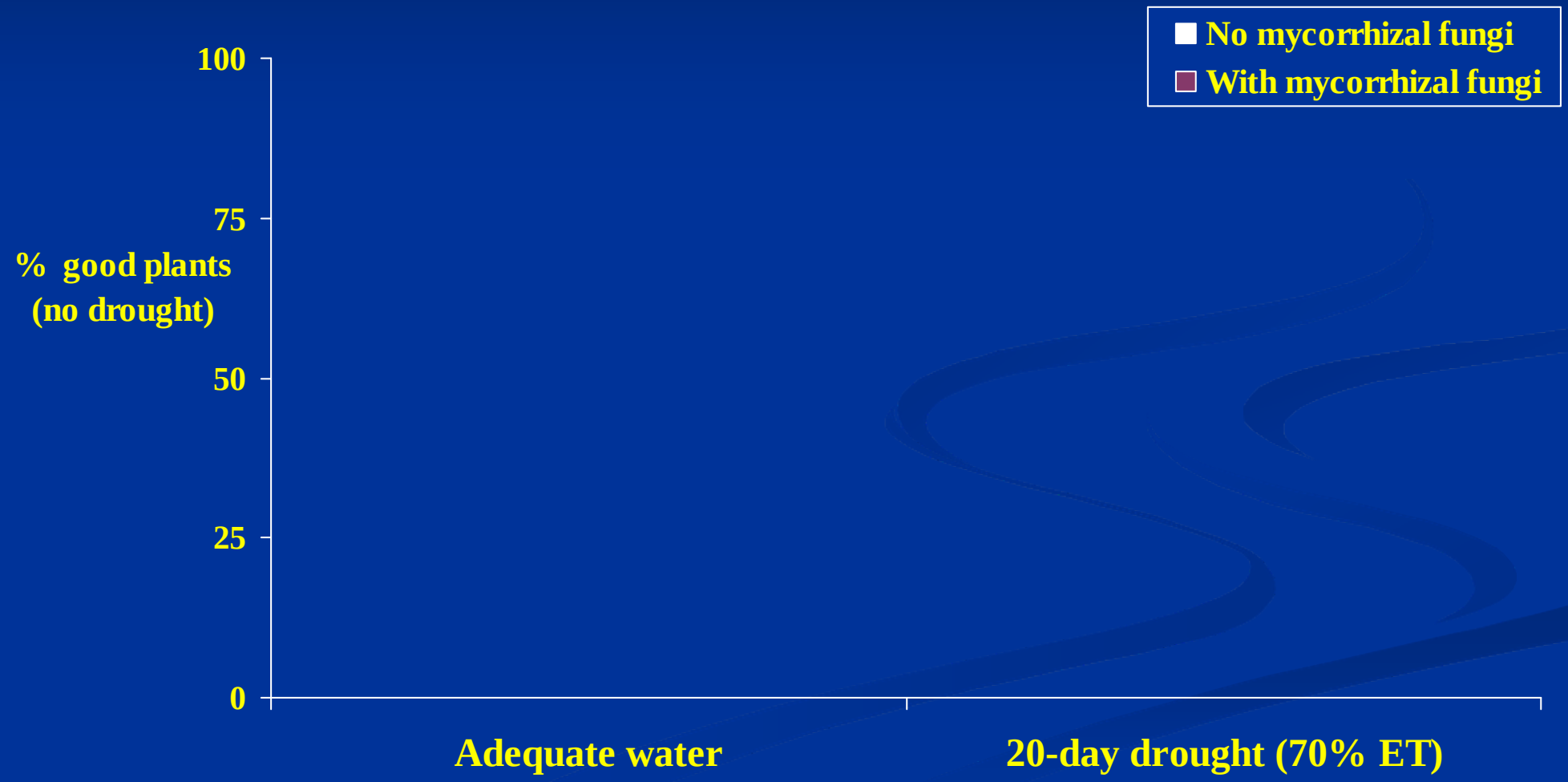
Adequate water

20-day water stress

Mycorrhizal fungi and water stress

Pepper plants (*Capsicum a.*) under different water regimes

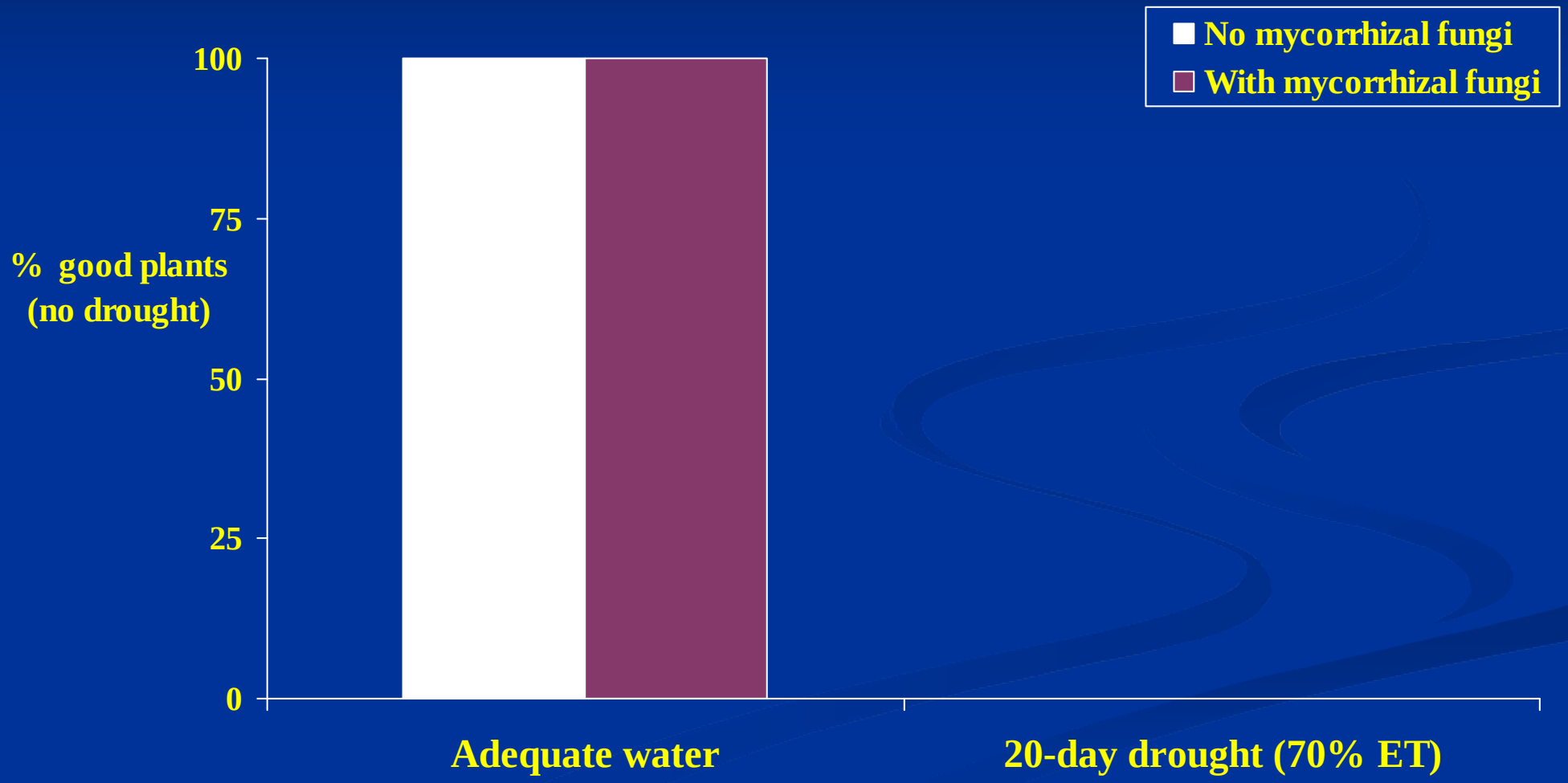
Adapted from F.T. Davies, Texas A&M University, ICOM 2003



Mycorrhizal fungi and water stress

Pepper plants (*Capsicum a.*) under different water regimes

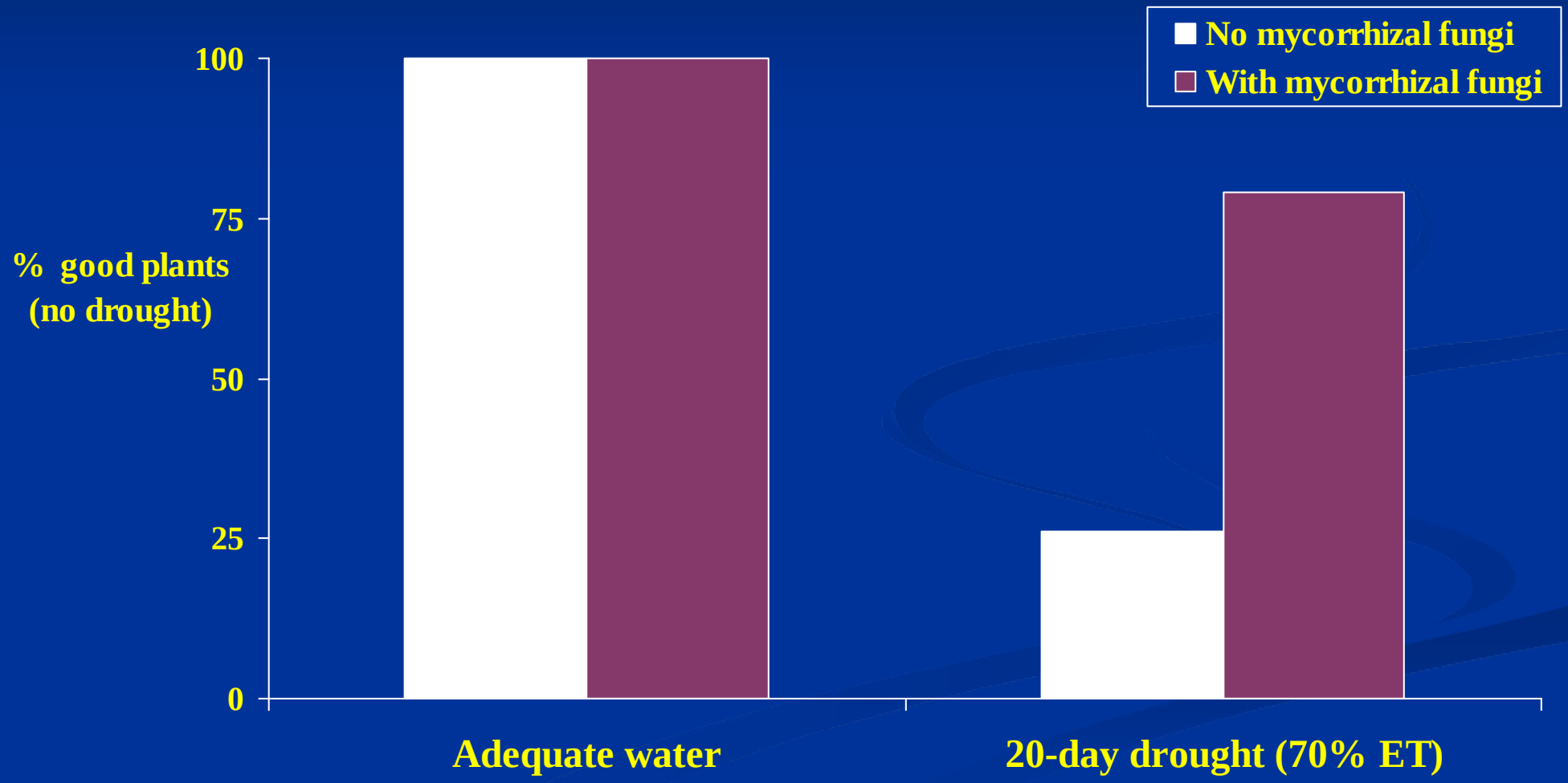
Adapted from F.T. Davies, Texas A&M University, ICOM 2003



Mycorrhizal fungi and water stress

Pepper plants (*Capsicum a.*) under different water regimes

Adapted from F.T. Davies, Texas A&M University, ICOM 2003



Mycorrhizal fungi and drought avoidance

From F.T. Davies, A&M University, ICOM 2003

- **Direct water transport**
  - Fungi may supply 10% of plant water need
  - Hyphal threads forage more soil surface
- **Better host nutrition**
  - Higher phosphorus and nitrogen in leaves
  - Current research: does P improve drought resistance?
- **Plant - osmotic adjustments**
  - Helps maintain leaf turgidity and photosynthesis rate
  - Current research: changes in soil – water relations

Question

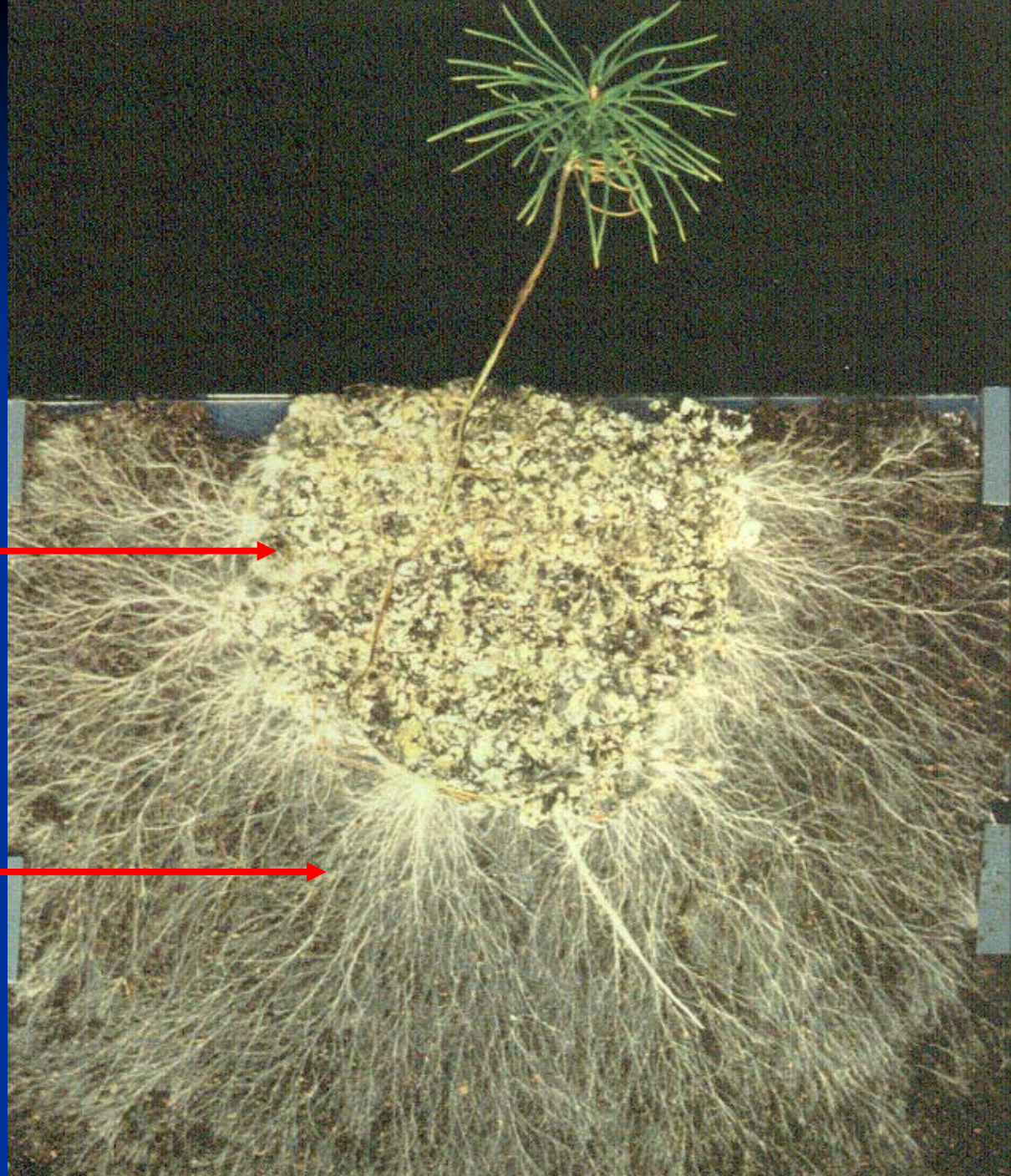
What is this “mycorrhizal fungi” ?

Mycelial network of ectomycorrhiza *Suillus b.* in association with *Pinus sylvestris*

Photo from J.R. Leake,
University of Sheffield, UK
Published in
Canadian Journal of Botany
2004

Roots of the plant

Hyphae of the fungus



Published online May 17, 2007

Special Section: Soil Biophysics
Vadose Zone Journal

Mycorrhizal Fungi: Highways for Water and Nutrients in Arid Soils

Michael F. Allen*

Mycorrhizal fungi are well known for increasing nutrient uptake but their effects on soil physical structure and water flow are less well understood. Here I explore what we know about the physical structure of mycorrhizal external mycelia and examine how that physical structure affects plant water uptake and reverse hydraulic lift in unsaturated soils. Mycorrhizal fungi are structured such that there are linear cytoplasmic units that can extend for a meter or more. Cell membranes may be only located in hyphal tips within the plant and externally several centimeters to meters distant from the plant root. Individual hyphae form a linear surface that goes across soil pores increasing the tortuosity factor (Γ) of the pathway for water flow, thereby increasing conductivity. But hyphae are small in diameter, providing only a small surface area for that transport. Little about the reverse flows (hydraulic redistribution from plant to fungus) is known other than that they occur and could play a critical role in sustaining hyphae through drought. The ultimate importance of mycorrhizae in plant–water relations depends on the drying patterns, the soil pore structure, and the number of hyphal connections extending from the root into the soil. New technologies are needed to adequately parameterize models of water horizontal flow patterns to: (i) observe and monitor the growth of roots and mycorrhizal fungi in situ; and (ii) describe the localized environment at high temporal and spatial resolution.

ABBREVIATIONS: AM, arbuscular mycorrhizae; EM, ectomycorrhizae.

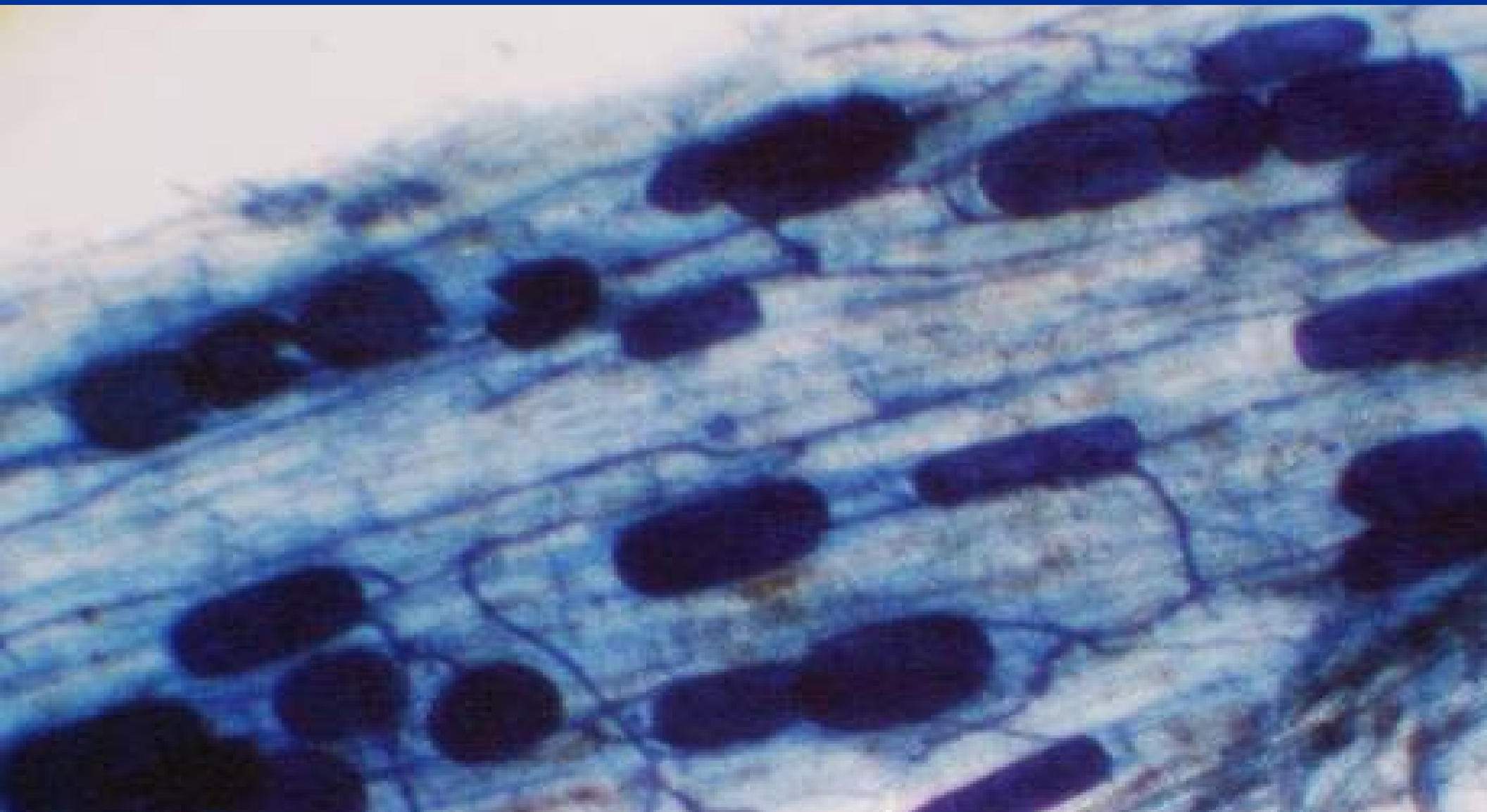
Mycorrhizal Associations

D.H. Marx, Plant Health Care Inc., 1997

- No mycorrhizal association
  - Early-succesSsion plants
  - Lamb's quarter, buckwheat, broccoli, spinach, beet
- Endo-mycorrhizal fungi
  - VAM, Ericaceous (rhododendron), Orchidaceous
  - Very common, occurs on 85% of green plants
  - Turf grass, vegetables, most shrubs, most trees
- Ecto-mycorrhizal fungi
  - On about 10% of plants, mostly late succession plants
  - Fir, spruce, pine, birch, beech, oak, linden, willow

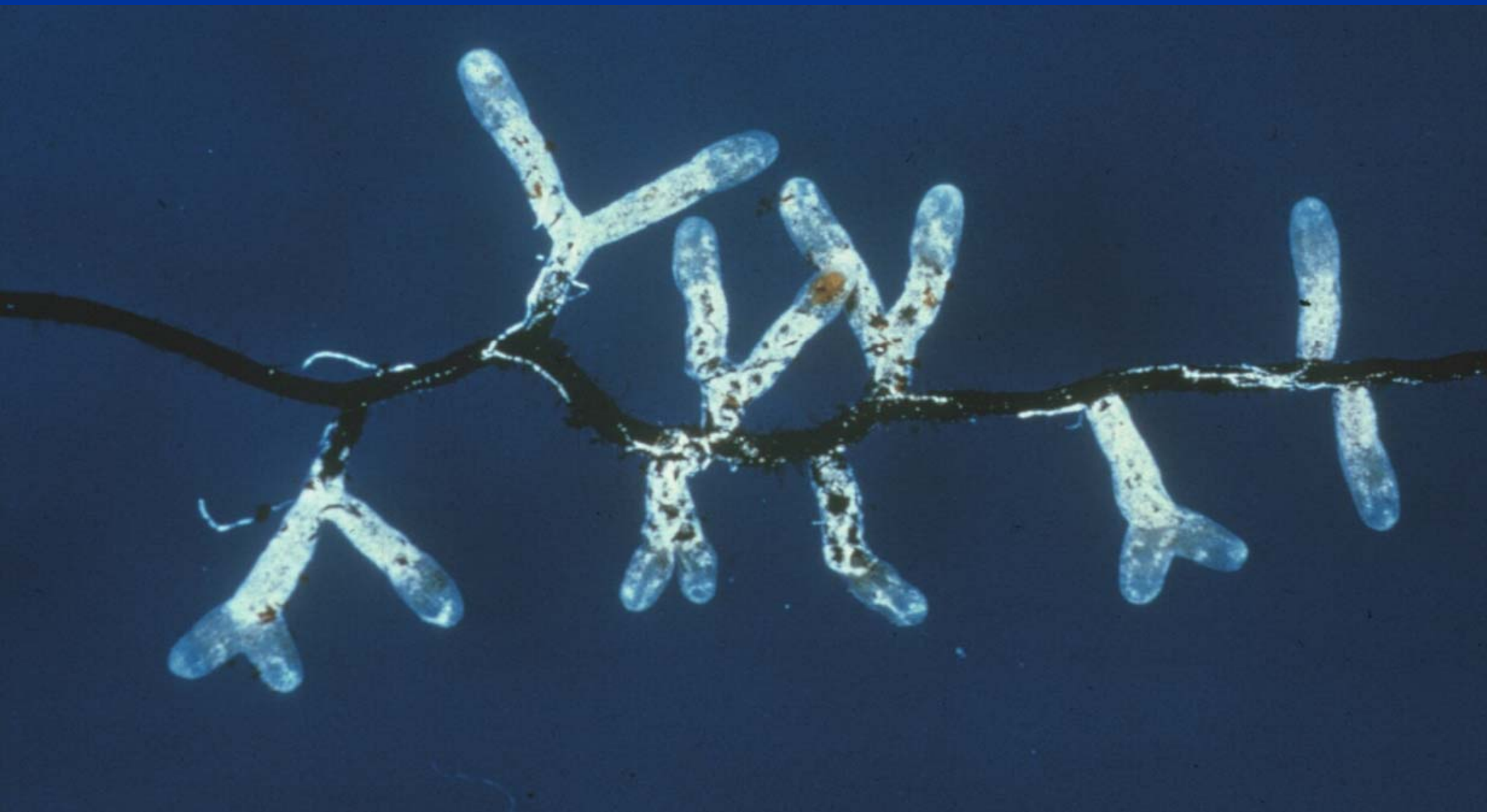
Endo-mycorrhizal fungi

Picture by E.R. Ingham, Soil Foodweb, Oregon



Ecto-mycorrhizal fungi

Picture by E.R. Ingham, Soil Foodweb, Oregon



We can see ecto-mycorrhizal fungi on roots

Golden chanterelles, ecto-mycorrhizal association in Douglas-fir and hemlock forests of the West Coast

Photo by T.F. Lockwood
US Department Agriculture
2003

Plants
that are colonised
by mycorrhizal fungi

have a higher tolerance
to environmental stresses

such as drought,
transplant, poor soil,
cold weather or root rot.

Question

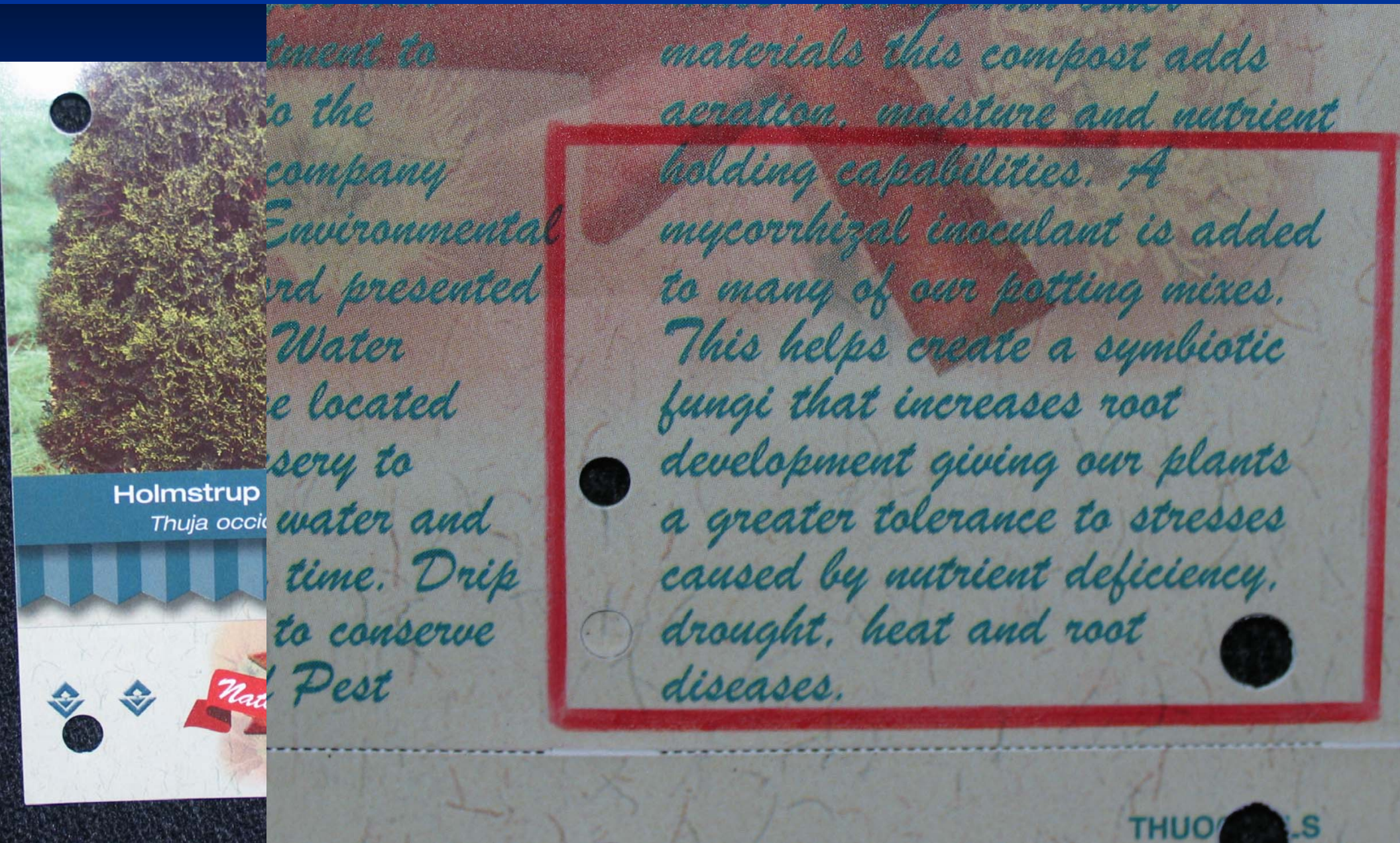
How can we ensure our plants
are inoculated with “mycorrhizal fungi” ?

Mycorrhizal fungi is most effective during propagation

Trials during production of perennial plants

More roots develop when using mycorrhizal fungi

Mycorrhizal fungi is used in nursery production



Mycorrhizal fungi is effective at the time of planting
Best use: apply directly over the roots

Products sold at garden centers

Products for commercial applications

Commercial bag

"endoRoots granular"
from Roots Inc.
California

Glomus mosseae
Glomus intraradices
Glomus deserticola
+ 5 other species

+
analysis 3 - 3 - 4
+
kelp meal
humus
amino acids

Mycorrhizal fungi and water stress

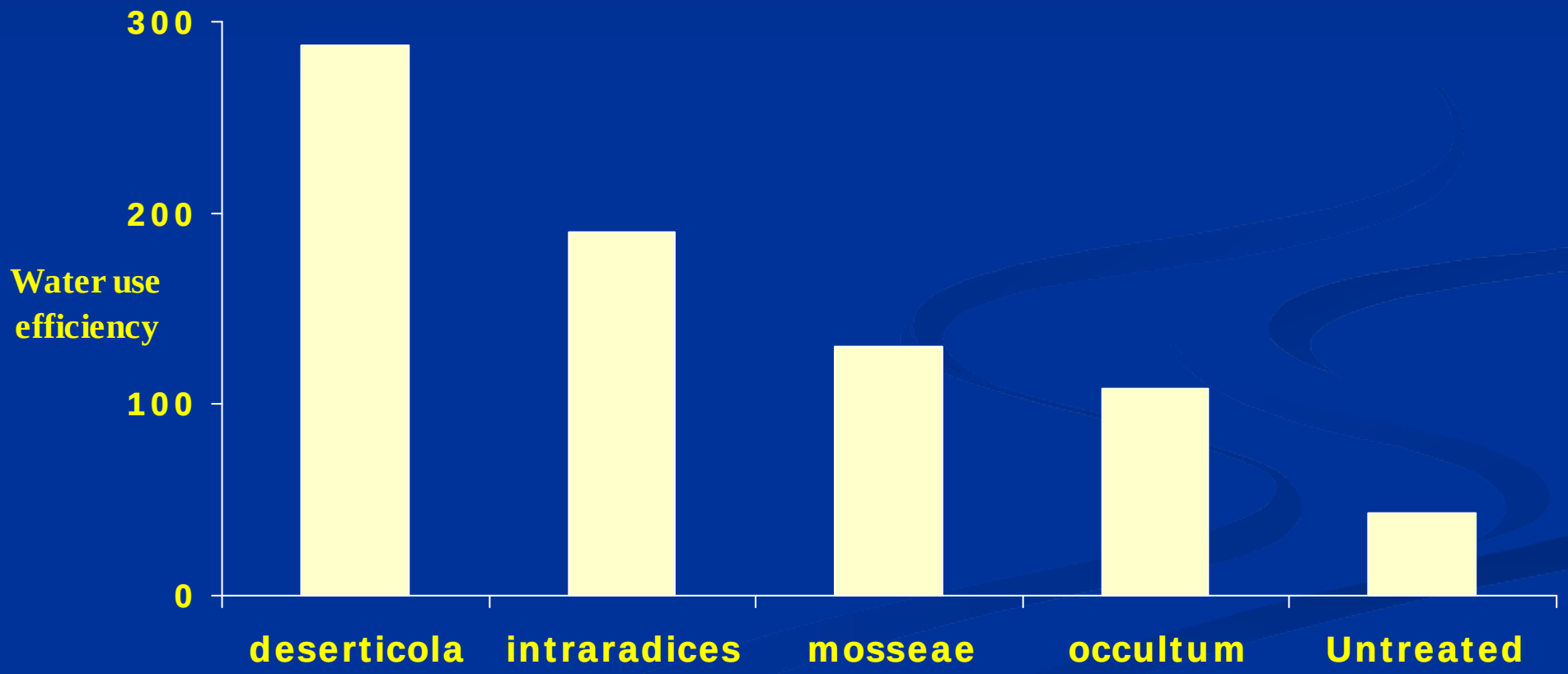
Study with *Glomus* species on lettuce subjected to water stress

Adapted from Ruiz-Lozano et al, App & Env Microbiology, 1995

Mycorrhizal fungi and water stress

Study with *Glomus* species on lettuce subjected to water stress

Adapted from Ruiz-Lozano et al, App & Env Microbiology, 1995



It also works for lawns

USGA Green Section Record – November/December
(Reprinted with permission from author)

MYCORRHIZAL FUNGI BENEFIT PUTTING GREENS

by R. Koske[1], J.N. GEMMA[2], and N. JACKSON[1] Department of Botany[1] and Department of Plant Sciences[2], University of Rhode Island, Kingston, Rhode Island

ENDOPHYTIC microorganisms occur in most species of plants as inhabitants of above- or below-ground organs. Their presence in the tissues either elicits no apparent effect in the normal functioning of the infected plants, or the endophytic may confer various benefits to the host. Grasses are no exception and present intriguing examples of these associations that can have application in turf management.

Fungi are the most frequently encountered partners with grasses, and several species that colonize leaves and stems are now known to confer protection from herbivores and environmental stresses. These properties are being exploited for turfgrass species, where resistance to depredation from surface-feeding insects is a major benefit. Unfortunately, these fungi do not inhabit root tissues, but, as in most plant roots, grass roots harbor other endophytic fungi, in particular, many species of vesicular-arbuscular mycorrhizal (VAM) fungi can be found. VAM endophytes have been extensively documented, and their beneficial effects on growth and development of a range of plant species have been demonstrated. However, the species involved and their biology and impact in the turf environment have received only cursory examination. In fact, there is a common belief that VAM fungi are of little importance in highly maintained turf where the extensive fine root system of the grasses receives ample water and nutrients that eliminate the requirement for the symbiosis. With the generous support of the USGA, a research project to investigate the subject of VAM in turf-grasses commenced at URI in 1990.

USGA Green Section Record – November/December
(Reprinted with permission from author)

MYCORRHIZAL FUNGI BENEFIT PUTTING GREENS

by R. Koske[1], J.N. GEMMA[2], and N. JACKSON[1] Department of Botany[1] and Department of Plant Sciences[2], University of Rhode Island, Kingston, Rhode Island

ENDOPHYTIC microorganisms occur in most species of plants as inhabitants of above- or below-ground organs. Their presence in the tissues either elicits no apparent effect in the normal functioning of the infected plants, or the endophytic may confer various benefits to the host. Grasses are no exception and present intriguing examples of these associations that can have application in turf management.

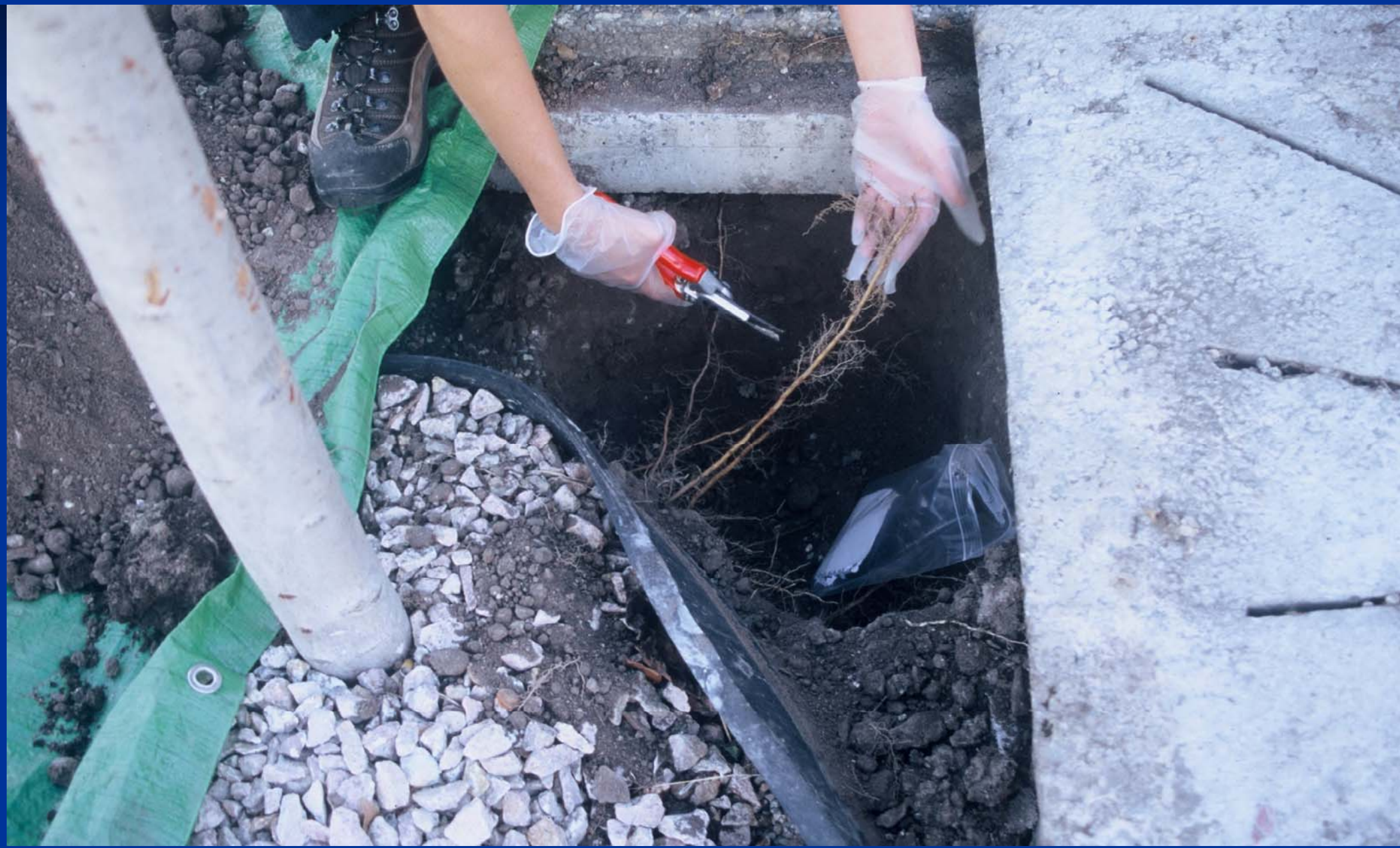
Fungi are the most frequently encountered partners with grasses, and several species that colonize leaves and stems are now known to confer protection from

In both field mini-plots and greenhouse trials in pots, mycorrhizal turf of Penncross survived drought conditions far better than did non-mycorrhizal turf.

After a five-day drought, mycorrhizal turf in the field study showed 39% less water stress than did control turf, and after eight days, the difference was 60%

Research in 2003 – 2004 with the City of Kelowna

Results are poor when applied on established plants



Mycorrhizae and urban plants

Donald H. Marx, Plant Health Care Inc., 1996

- Possible applications
  - The plant is a known mycorrhizal host.
  - The soil is poor quality, small volume, or not irrigated.
- Potential benefits
  - Increased tolerance to transplant, drought, stress, and root rot.
  - Improved availability of nutrients.
- To encourage root colonisation
  - Inoculate prior to transplanting.
  - Maintain adequate water and fertiliser, mulch if possible.

Thank you !

See you after the break