
Fluid Fertilizer Foundation
Solutions for AGRICULTURE
ACADIAN SEAPLANTS LIMITED
Acadian AGRITECH
ADVANCES IN THE USE OF ASCOPHYLLUM NODOSUM SEAPLANT EXTRACTS FOR CROP PRODUCTION
LINKING LABORATORY AND FIELD RESEARCH
Jeffrey Norrie, Ph.D., P.Ag. CPH
Acadian Seaplants Ltd., Dartmouth, Nova Scotia, Canada

Major Processing Facilities

Prince Edward Island

New Brunswick

Pennfield, NB

Nova Scotia

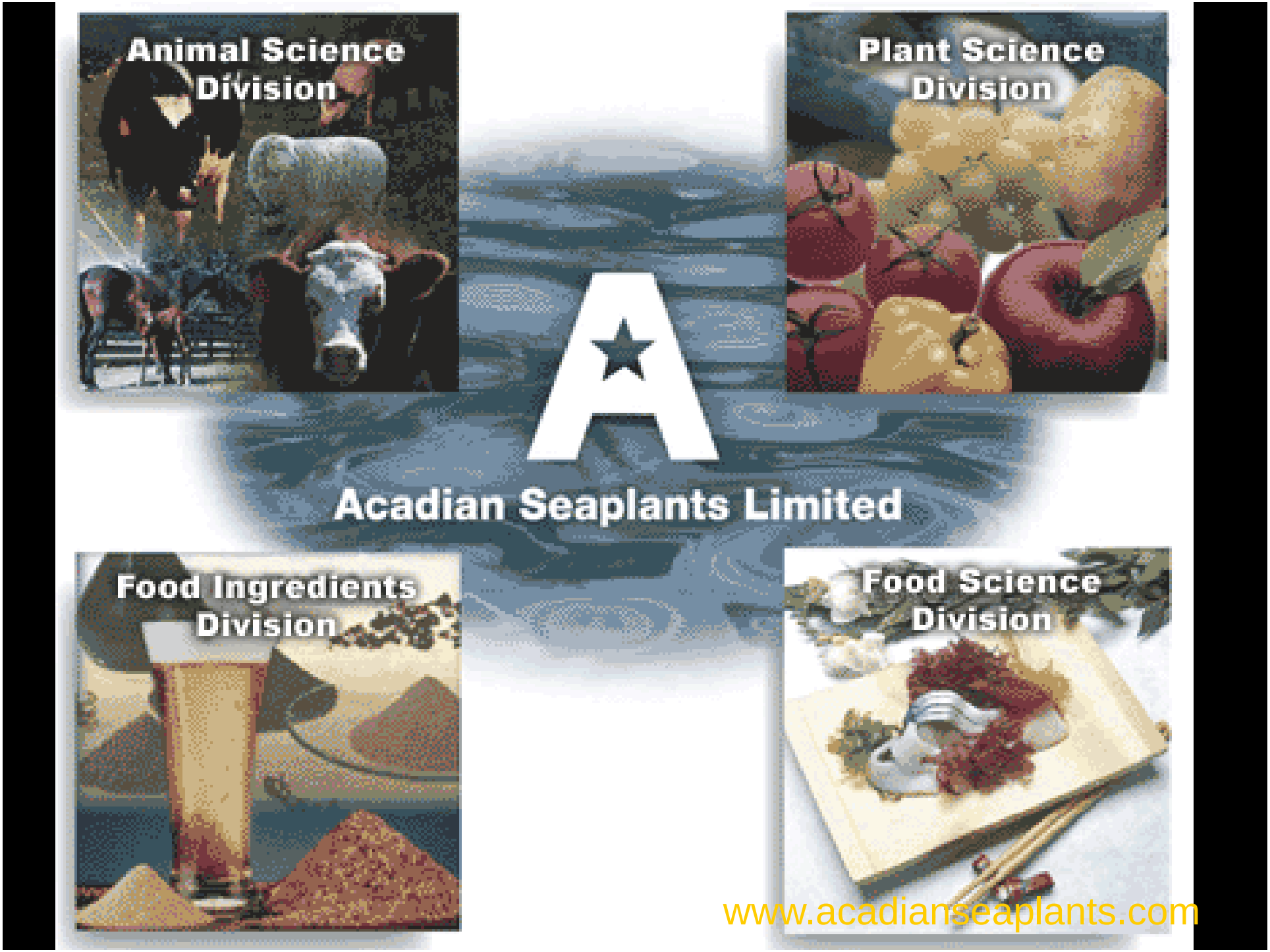
Head Office
Dartmouth, NS

Cornwallis, NS

Yarmouth, NS

Maine, USA

Charlesville, NS


Animal Science Division
Plant Science Division
Acadian Seaplants Limited
Food Ingredients Division
Food Science Division
www.acadianseaplants.com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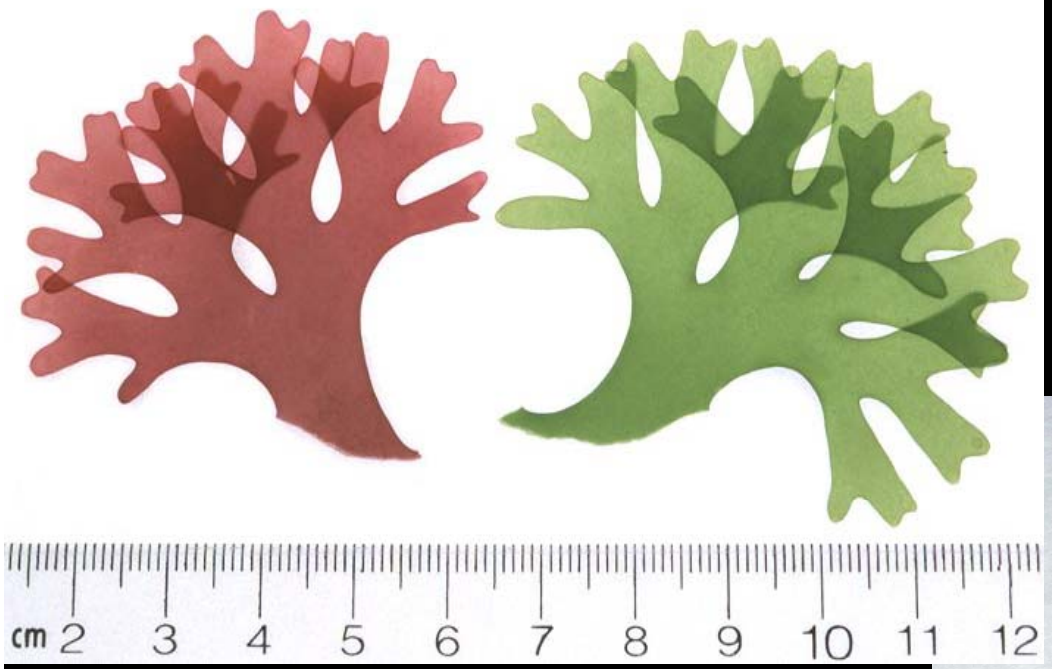
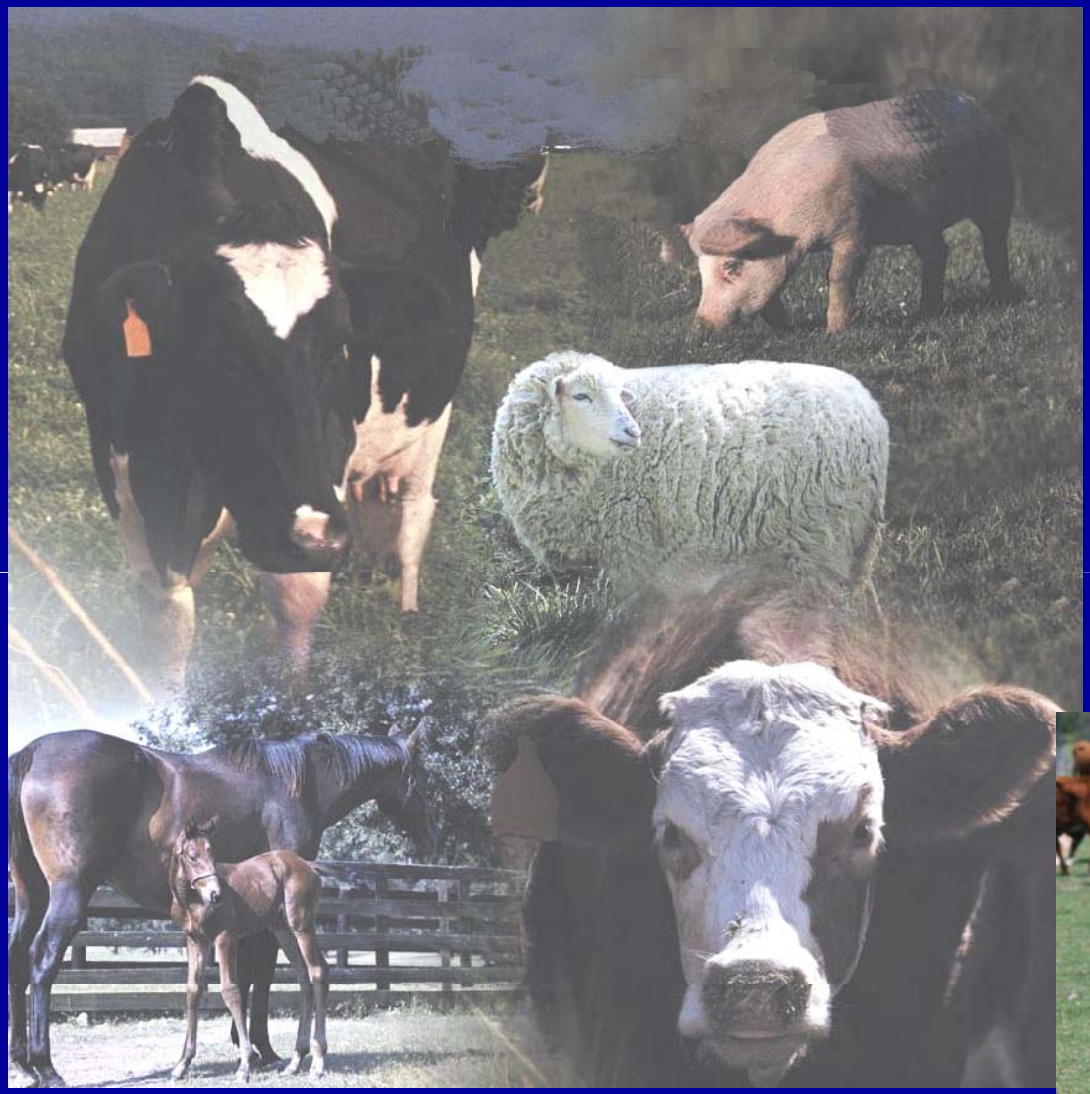
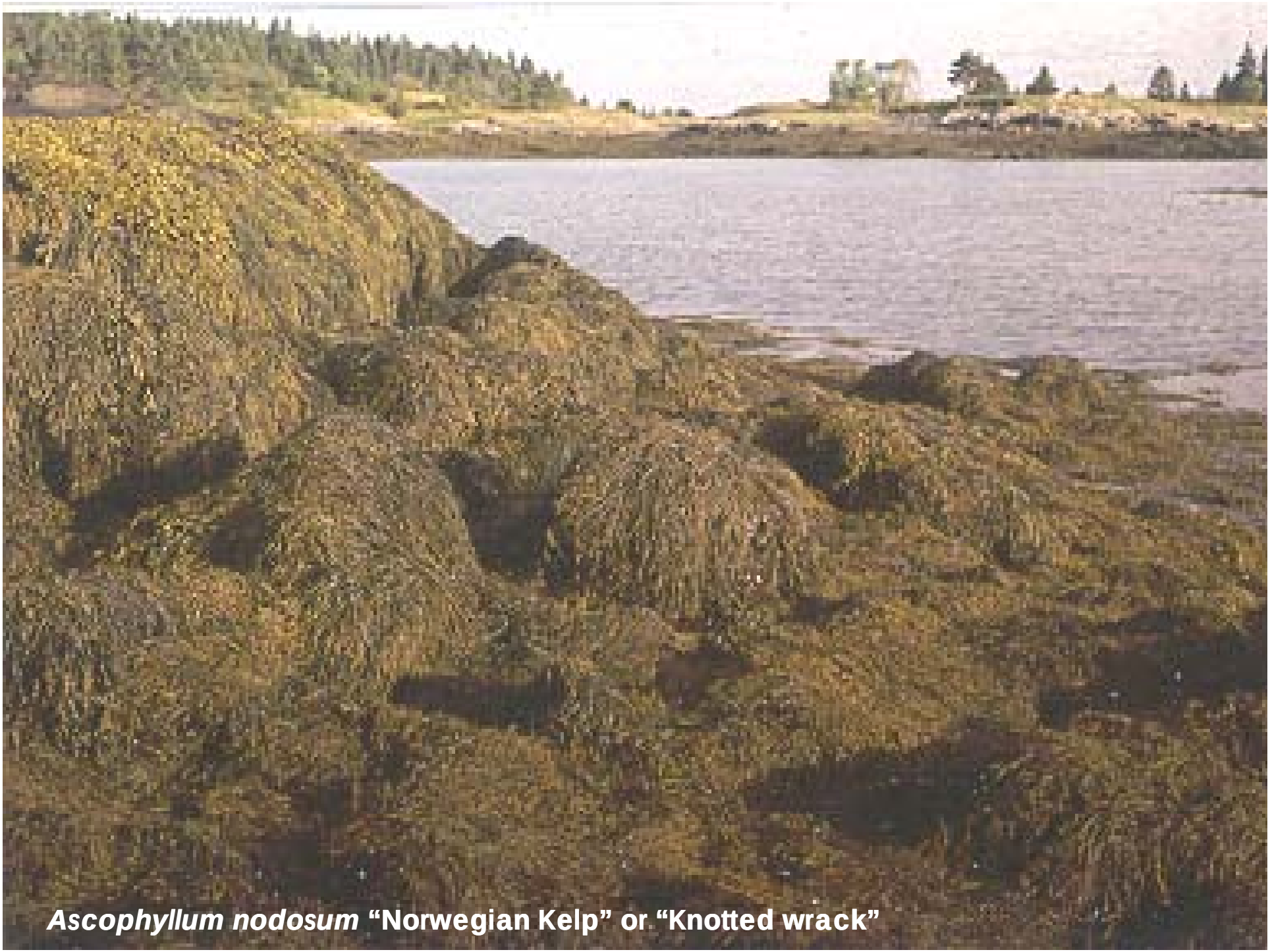
Acadian Seaplants
Les Algues Acadiennes

Hana-nori™





Alimentation animale



Ascophyllum nodosum **“Norwegian Kelp” or “Knotted wrack”**

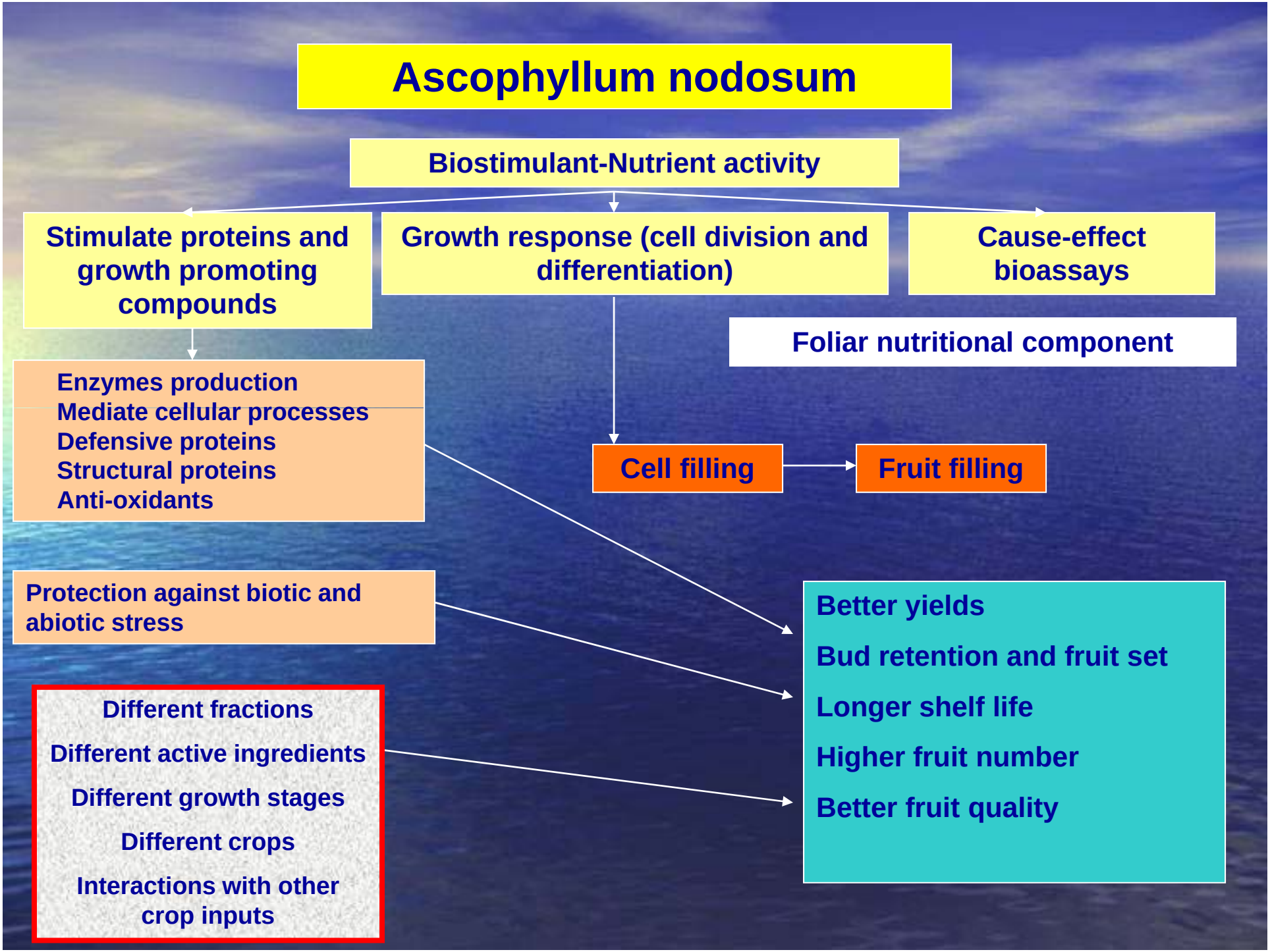

Bay of Fundy

R&D Challenges

- Main product for agriculture:
  - ***Ascophyllum nodosum*** algal extracts
- Research from lab to field on achieving maximum benefit from seaweed extracts
- Technology Transfer of information to Sales and Marketing
- Get best-use information into the hands of growers and market partners

R&D Challenges

- Different countries, different crops, different varieties, different growing conditions (soil, water, atmosphere, crop programs)
  - Research field trials, coop trials, joint trials
- Draw on expertise from greater scientific community to examine seaweed products to understand best use strategies


Ascophyllum nodosum
Biostimulant-Nutrient activity
Stimulate proteins and growth promoting compounds
Growth response (cell division and differentiation)
Cause-effect bioassays
Foliar nutritional component
Enzymes production
Mediate cellular processes
Defensive proteins
Structural proteins
Anti-oxidants
Cell filling
Fruit filling
Protection against biotic and abiotic stress
Different fractions
Different active ingredients
Different growth stages
Different crops
Interactions with other crop inputs
Better yields
Bud retention and fruit set
Longer shelf life
Higher fruit number
Better fruit quality

Challenge

- Sensitivity
  - How do we show differences between treatments?
  - Remove experimental error
- Cause and effect
- Provide scientific explanations
- Data Data Data

ASL R&D Center for Innovation

Cornwallis Business Park, Clementsport, Nova Scotia

Benefits of *Ascophyllum* extracts

- Many benefits are attributed to seaweed extracts
  - How are these identified?
- How do we best use seaweed extracts in Agriculture?
- Starts with examination of our species, extraction technology and base constituents.

What is *Ascophyllum* Seaweed Extract?

- A Complex mix of:
  - Plant growth regulators
    - Auxins, Gibberellins, Cytokinins, Betaines,
  - Amino acids
  - Organic acids
  - Carbohydrates
  - Vitamins
  - Macro- and micro-nutrients

Plant Growth Hormones

CYTOKININS
Trans-zeatin
dihydro-zeatin
dihydro-zeatin riboside
trans-zeatin riboside
Isopentyladenosine
isopentyladenoside

AUXINS
Indole acetic acid

ABSCISSIC ACID

GIBBERELLINS
GA_3
GA_4

Other Bioactives of Interest

Oligosaccharides

Polyphenolics

Betaine Levels (ppm)

Sample	GB	ABAB	AVAB
***A. nodosum* M1**	15-30	150-350	50-60
SSEP	30-60	130-260	100-200

Acadian Seaplants R&D

- What kinds of projects are we looking at?
  - Active ingredient identification:
    - HPLC technologies
      - Carbohydrate profiling
      - Plant Hormones
    - Gas Chromatography/Mass spectrometry
      - Specific molecules
    - NMR technologies
      - Comparative profiles of molecular constituents
  - In vivo testing

NMR Spectra of ASL Extracts

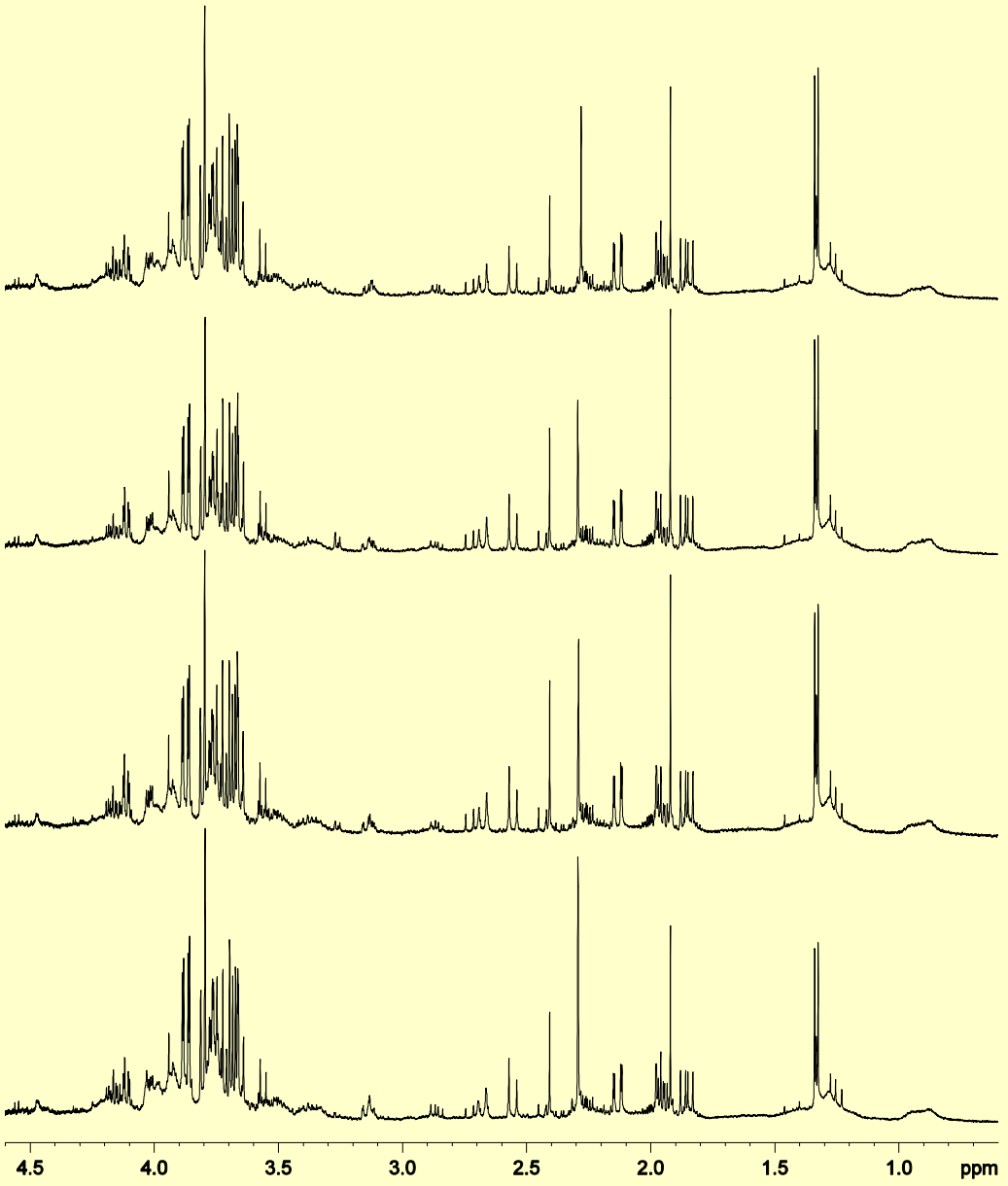
Localities and Seasons

Ingomar NS **Sep** 2004

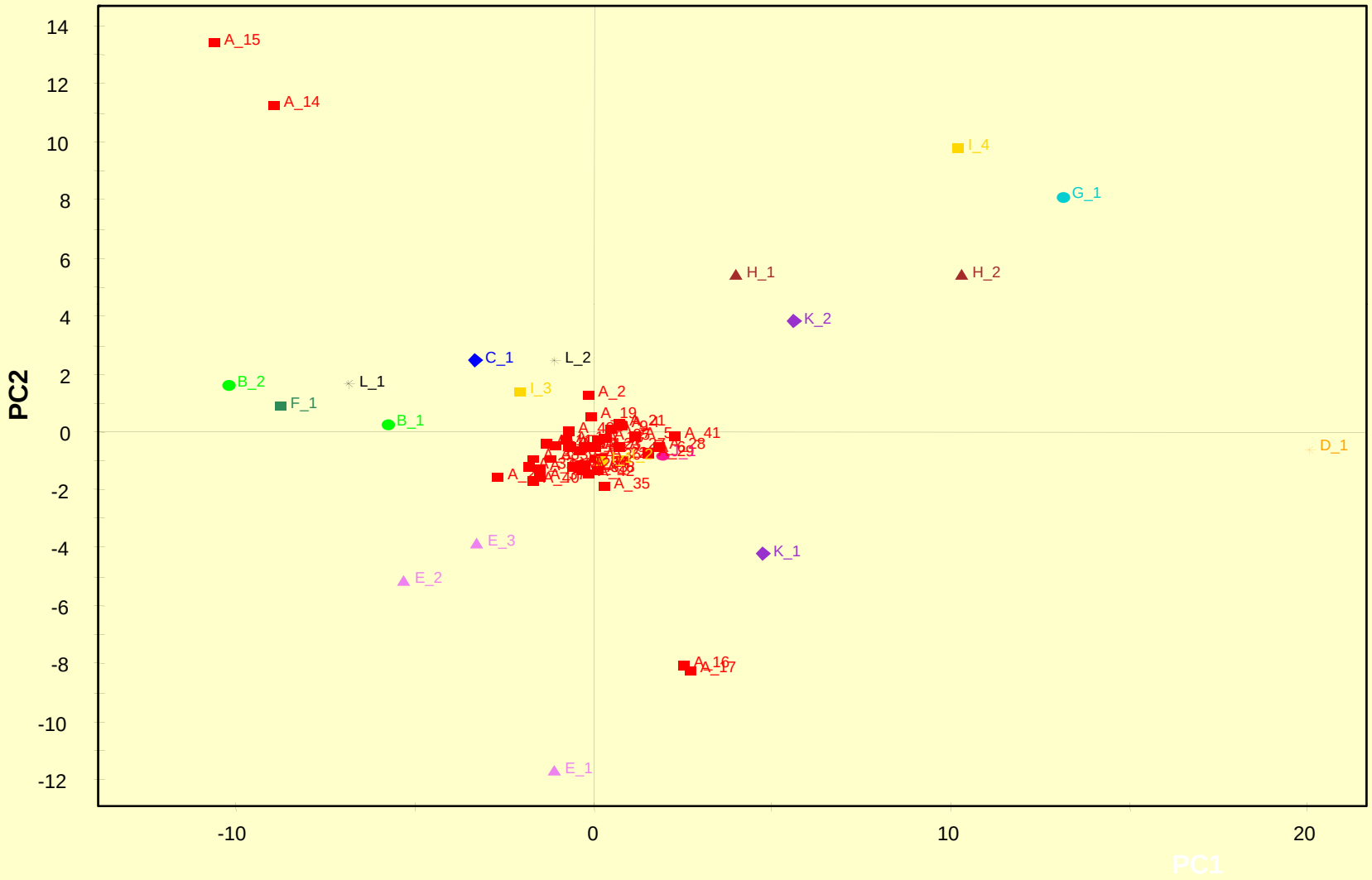
Barrington NS **Jun** 2004

Bear Point NS **Mar** 2004

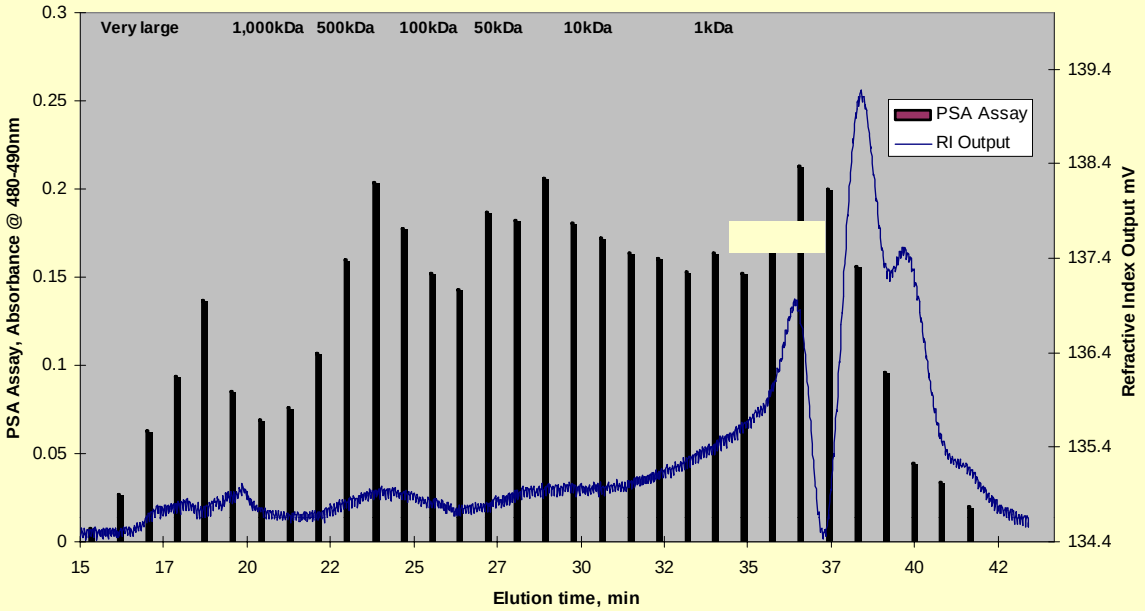
Glenwood NS **Jan** 2004



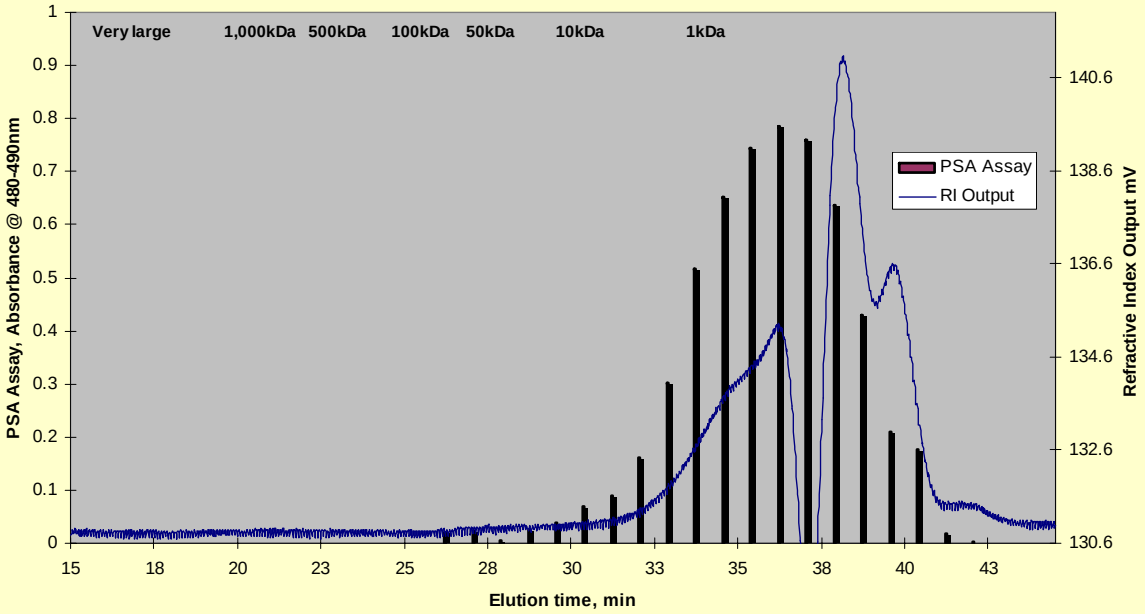
Principal Components Analysis of ^{1}H-NMR Spectra



HPLC Ultahydrogel Profile with PSA Assay
Acadian SSEP 4318 (A1-04)

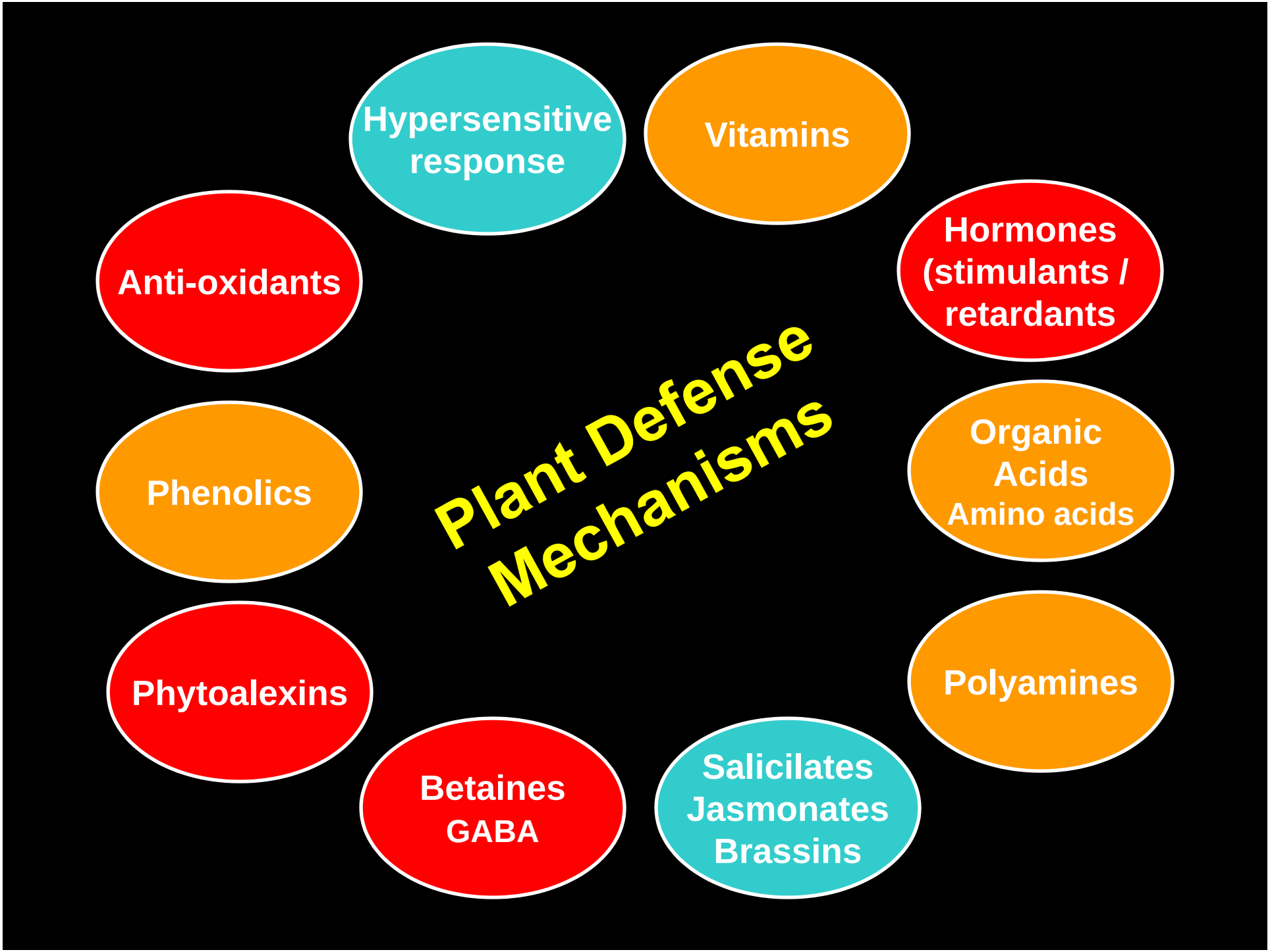


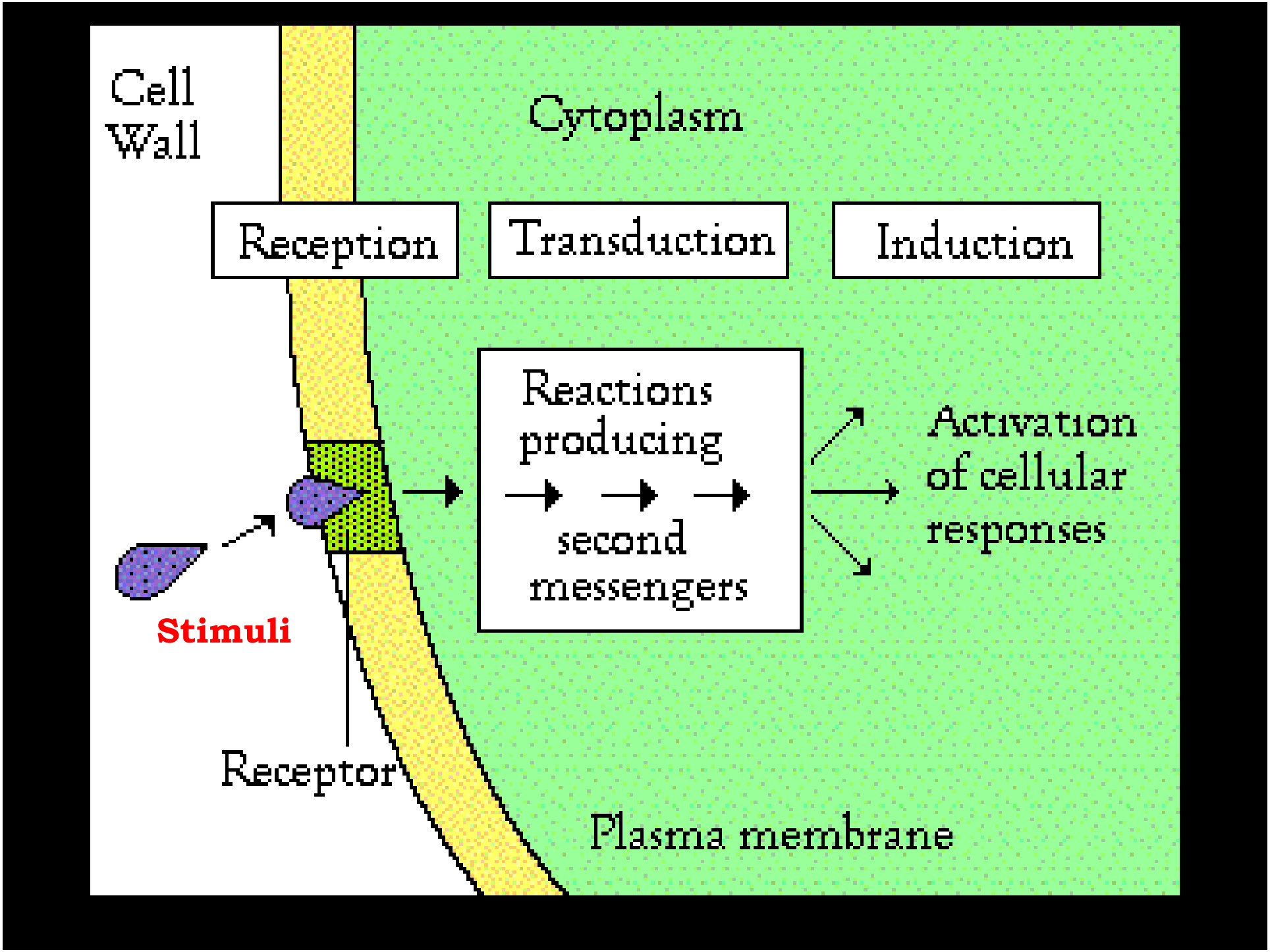
HPLC Ultahydrogel Profile with PSA Assay
LSE Pressurized Cook



Points to Consider

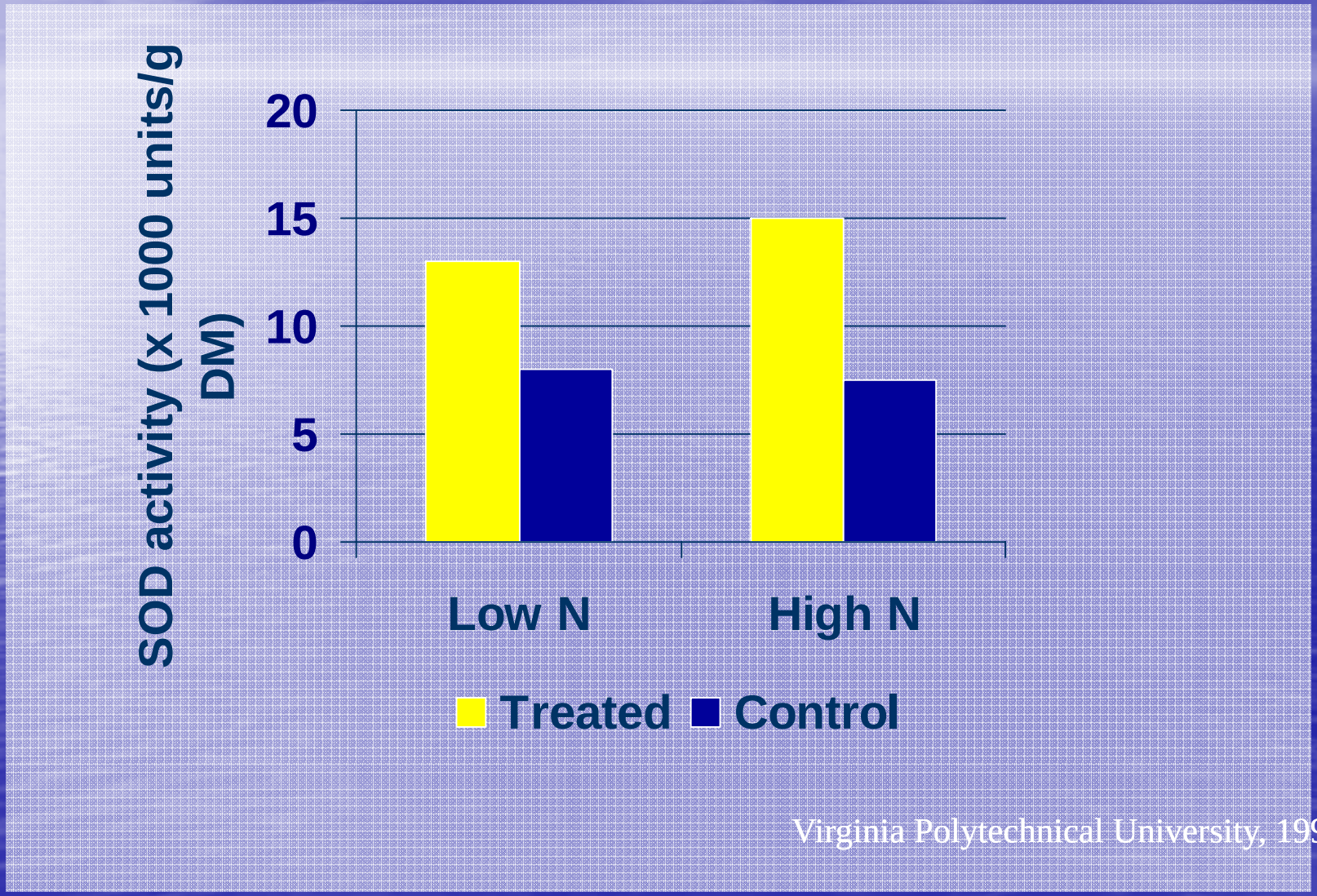
- Different seaweed products are made in different ways.
- Different products have different bioactivities
- Need to identify these actives in various marine plant products
- Need to connect activities to specific plant responses
- Genetic/molecular responses


Plant Defense Mechanisms
Hypersensitive response
Vitamins
Anti-oxidants
Hormones (stimulants / retardants
Phenolics
Organic Acids
Amino acids
Phytoalexins
Polyamines
Betaines
GABA
Salicilates
Jasmonates
Brassins


Cell Wall
Cytoplasm
Reception
Transduction
Induction
Reactions producing second messengers
Activation of cellular responses
Stimuli
Receptor
Plasma membrane

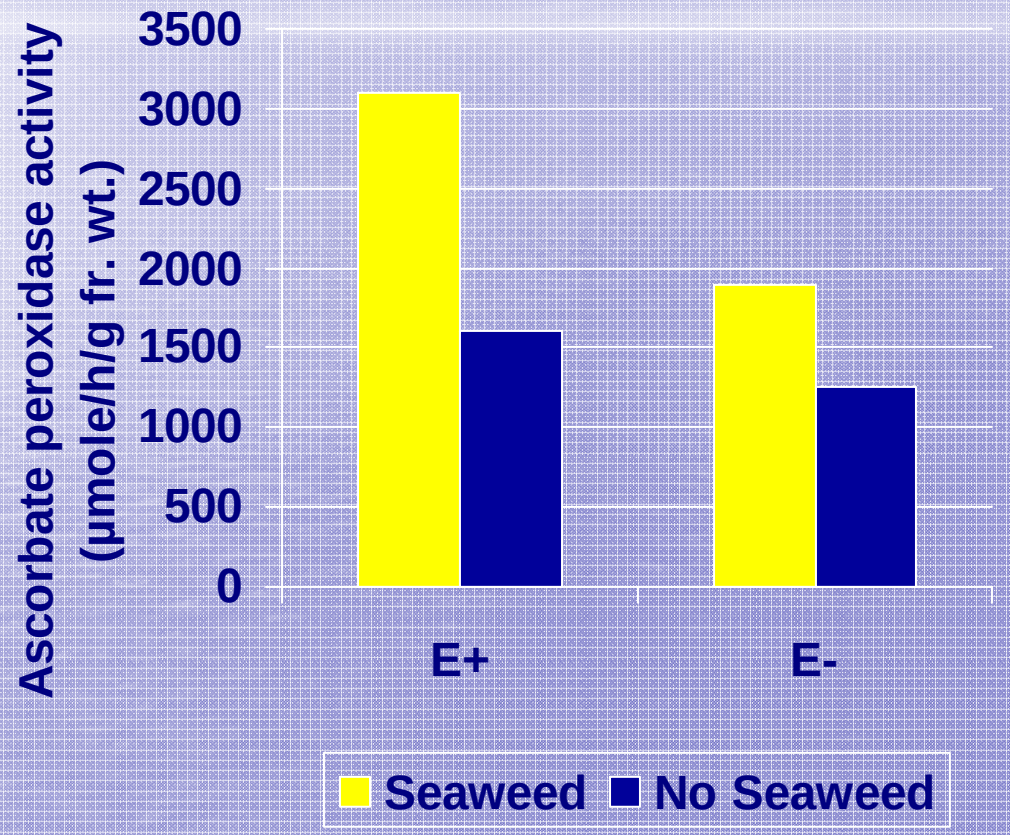
Stress Resistance

Superoxide dismutase in creeping bentgrass



Virginia Polytechnical University, 1997

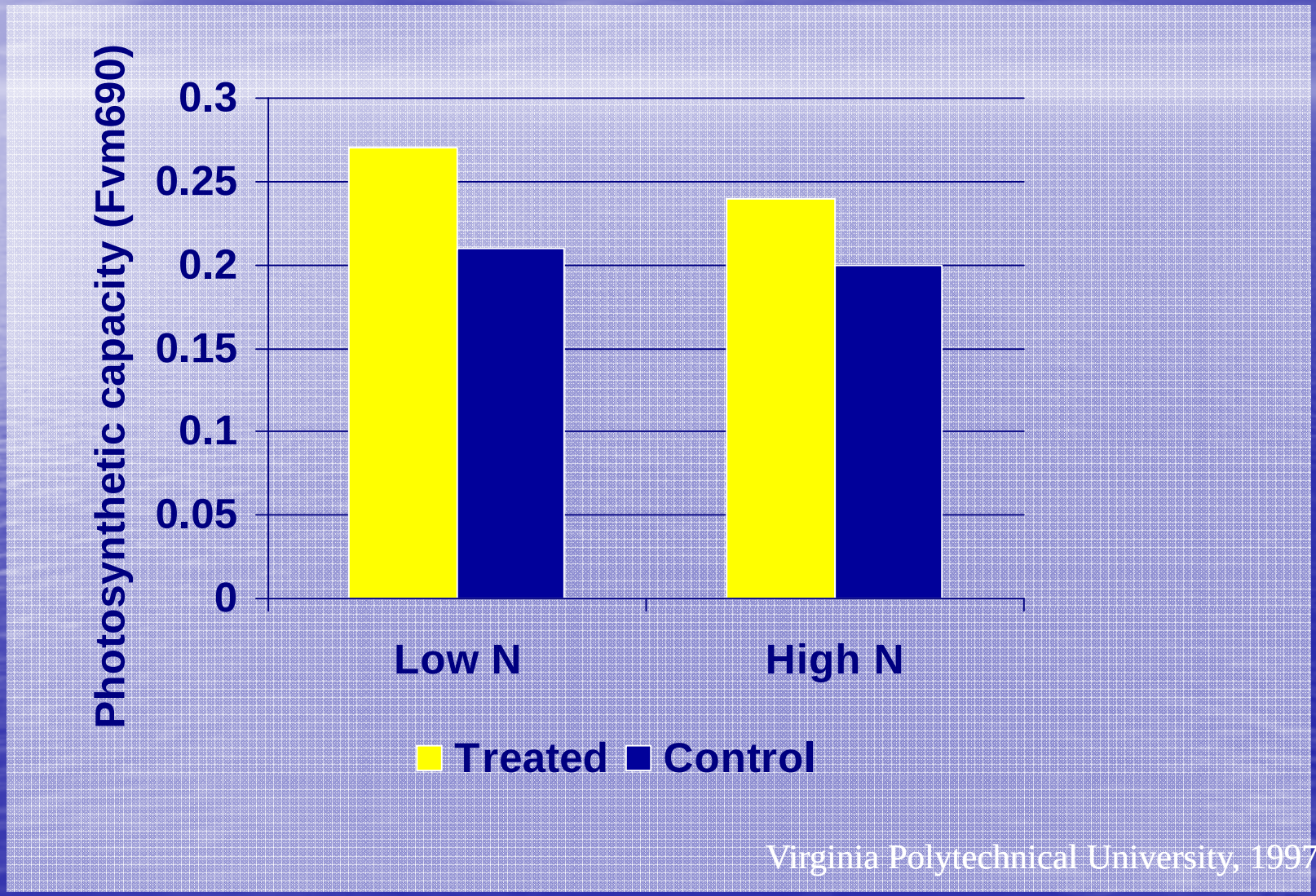
Ascorbate peroxidase activity in tall fescue



Virginia Polytechnical University, 1997

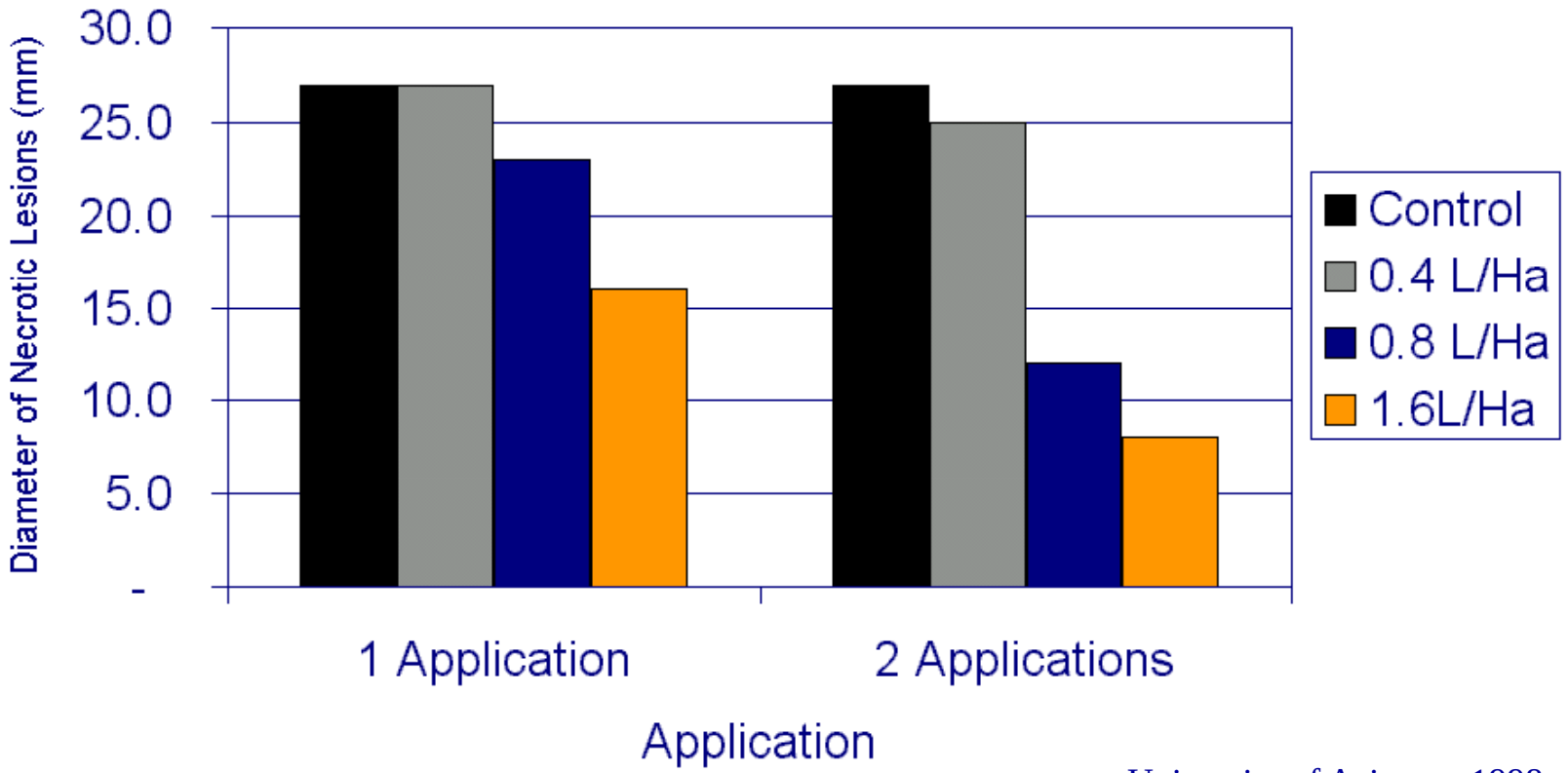
P/S capacity in creeping bentgrass

Improves photosynthetic efficiency



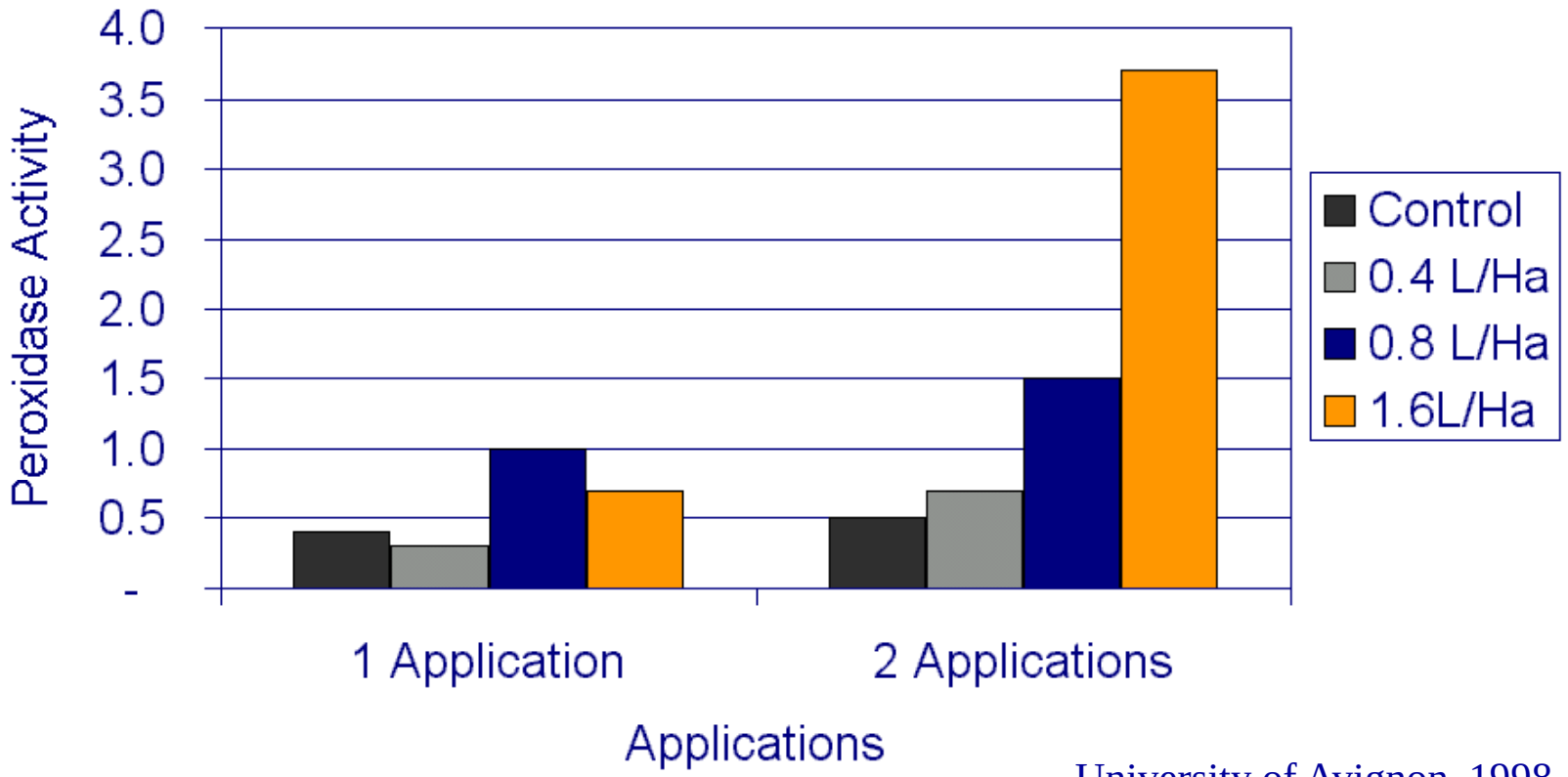
Virginia Polytechnical University, 1997

Resistance to Disease Stress

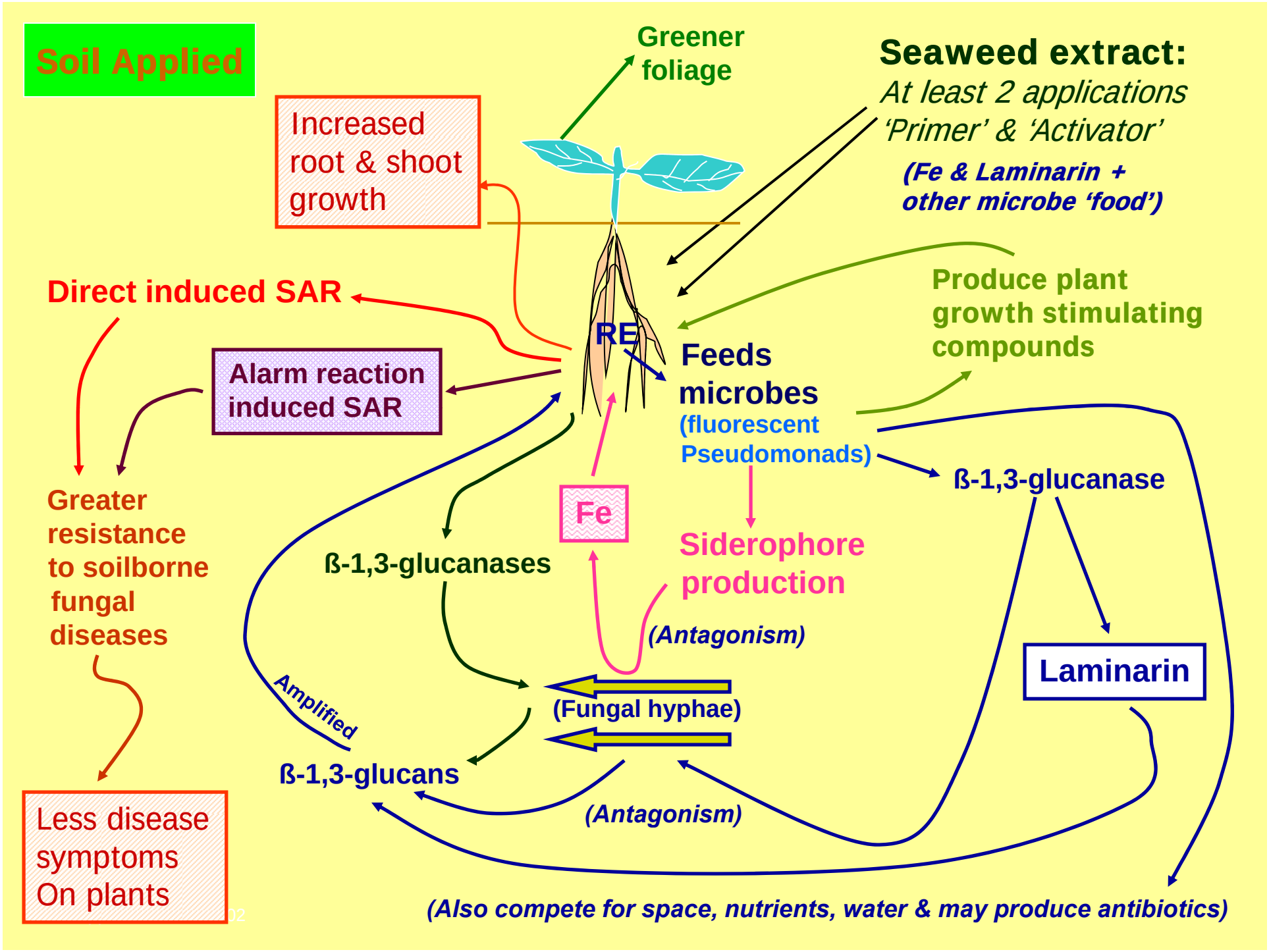


University of Avignon, 1998

Resistance to Disease Stress



University of Avignon, 1998


Soil Applied
Greener foliage
Seaweed extract:
At least 2 applications
'Primer' & 'Activator'
(Fe & Laminarin + other microbe 'food')
Increased root & shoot growth
Direct induced SAR
Alarm reaction induced SAR
RE
Feeds microbes
(fluorescent Pseudomonads)
Produce plant growth stimulating compounds
Greater resistance to soilborne fungal diseases
ß-1,3-glucanases
Fe
Siderophore production
ß-1,3-glucanase
(Antagonism)
Laminarin
Amplified
(Fungal hyphae)
ß-1,3-glucans
(Antagonism)
Less disease symptoms On plants
(Also compete for space, nutrients, water & may produce antibiotics)

Acadian Seaplants R&D

Focus

- **Increased crop growth & quality:**
  - **From plant establishment to harvest**
- **Enhanced crop resistance to abiotic and biotic stresses:**
  - **Drought, salinity, heat, chilling, frost, water-logging, etc**
  - **Disease and Insects**
- **Provide commercially relevant technical knowledge:**
  - **Market support for *Ascophyllum* products.**

Acadian Seaplants R&D

- Bioassay testing for bioactivity
- Processing development
- Formulation of active fractions
- Shelf-life studies
- Greenhouse efficacy testing
- Local replicated field trials
- Target market replicated field trials
- Commercialization and release of information

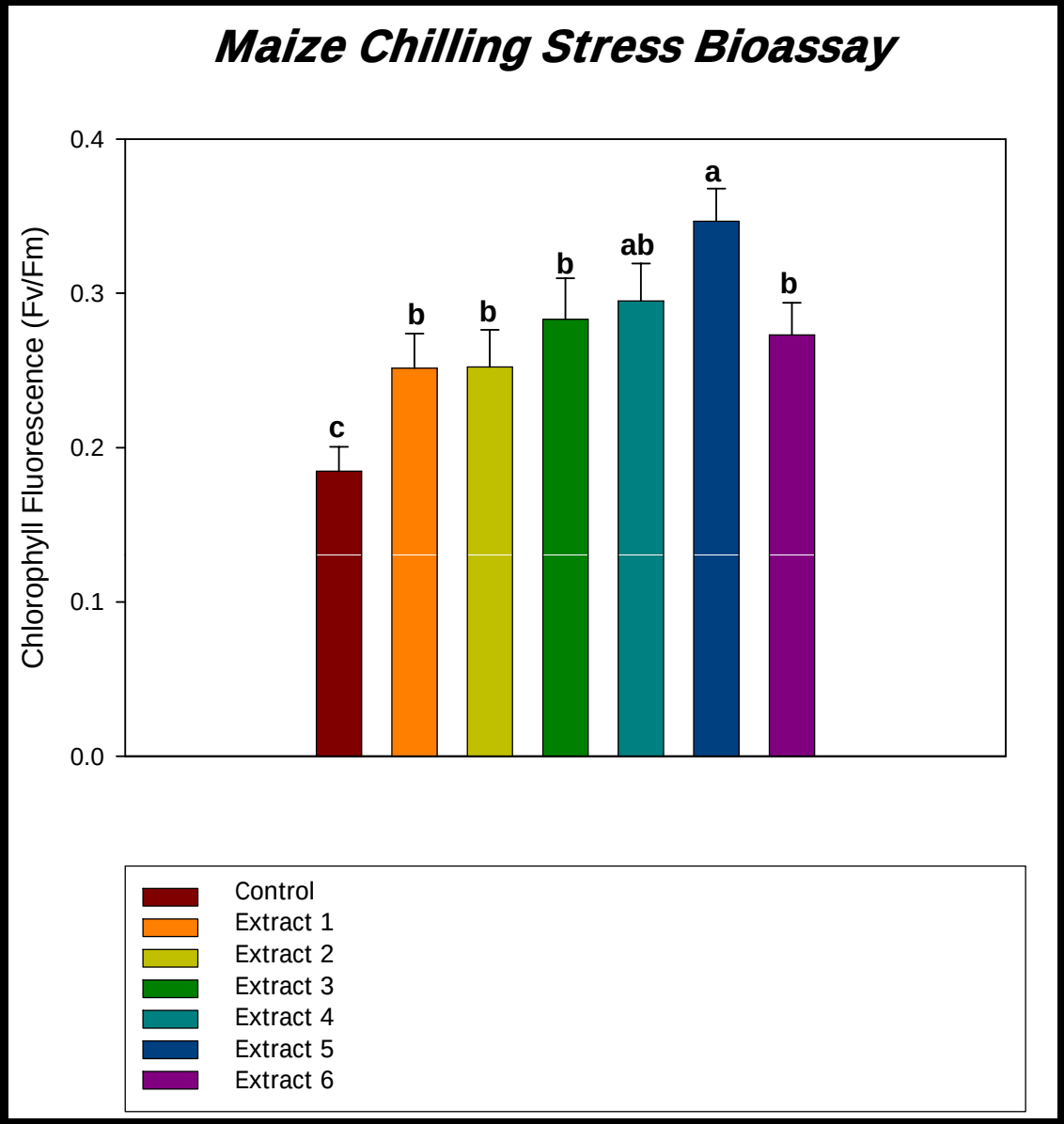


Figure 20. ***Bioactivity (Maize Chilling Stress Bioassay (MCSB)) of controls (applied at 100 mg/l or equivalent. Different letters indicate significantly different means between treatments (α = 5%). Error bars (fractions) represent standard error (SE). (n = 30)***

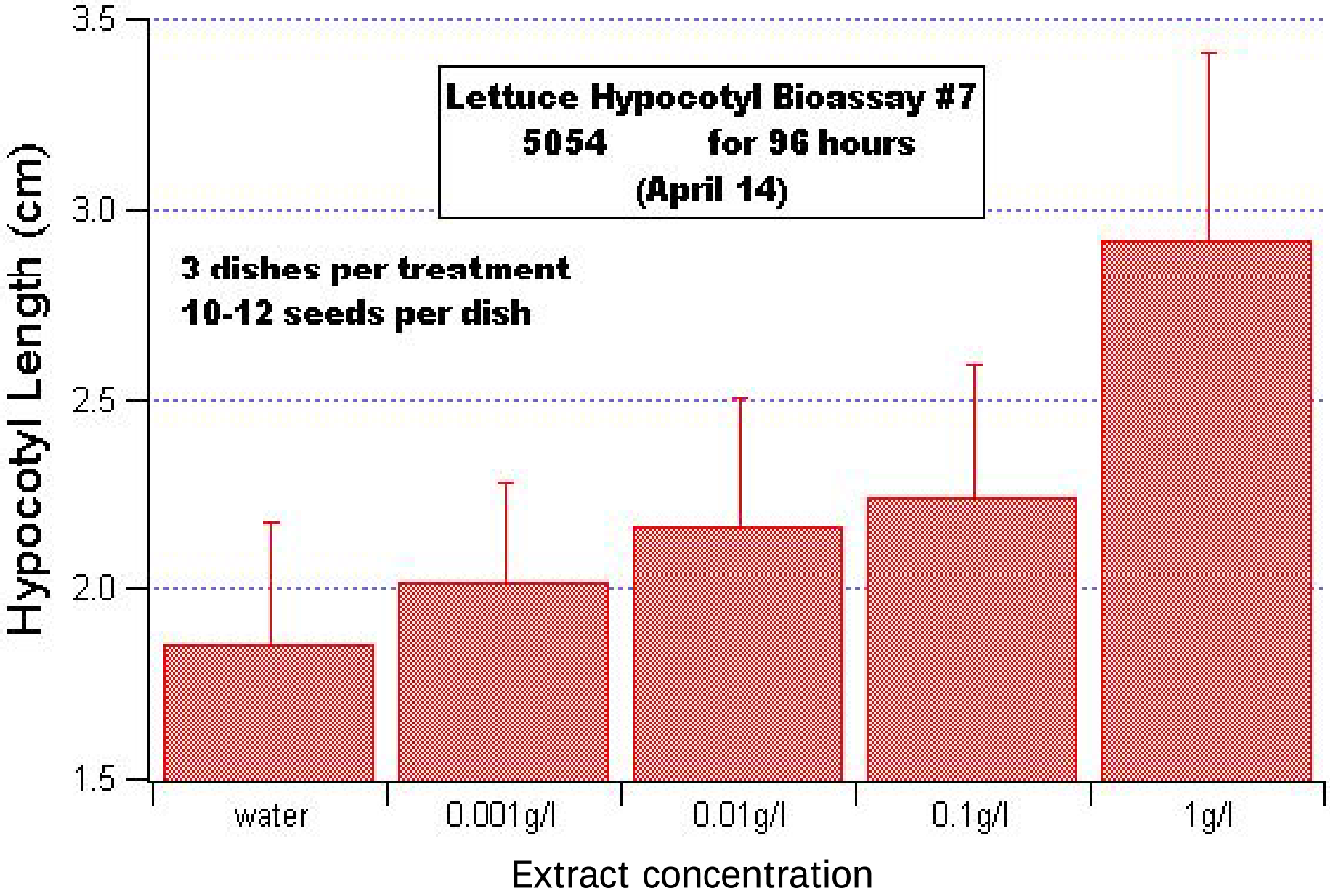


Figure 2. *Effect of batch 5054 on lettuce hypocotyls elongation in the dark after 96 hours.*

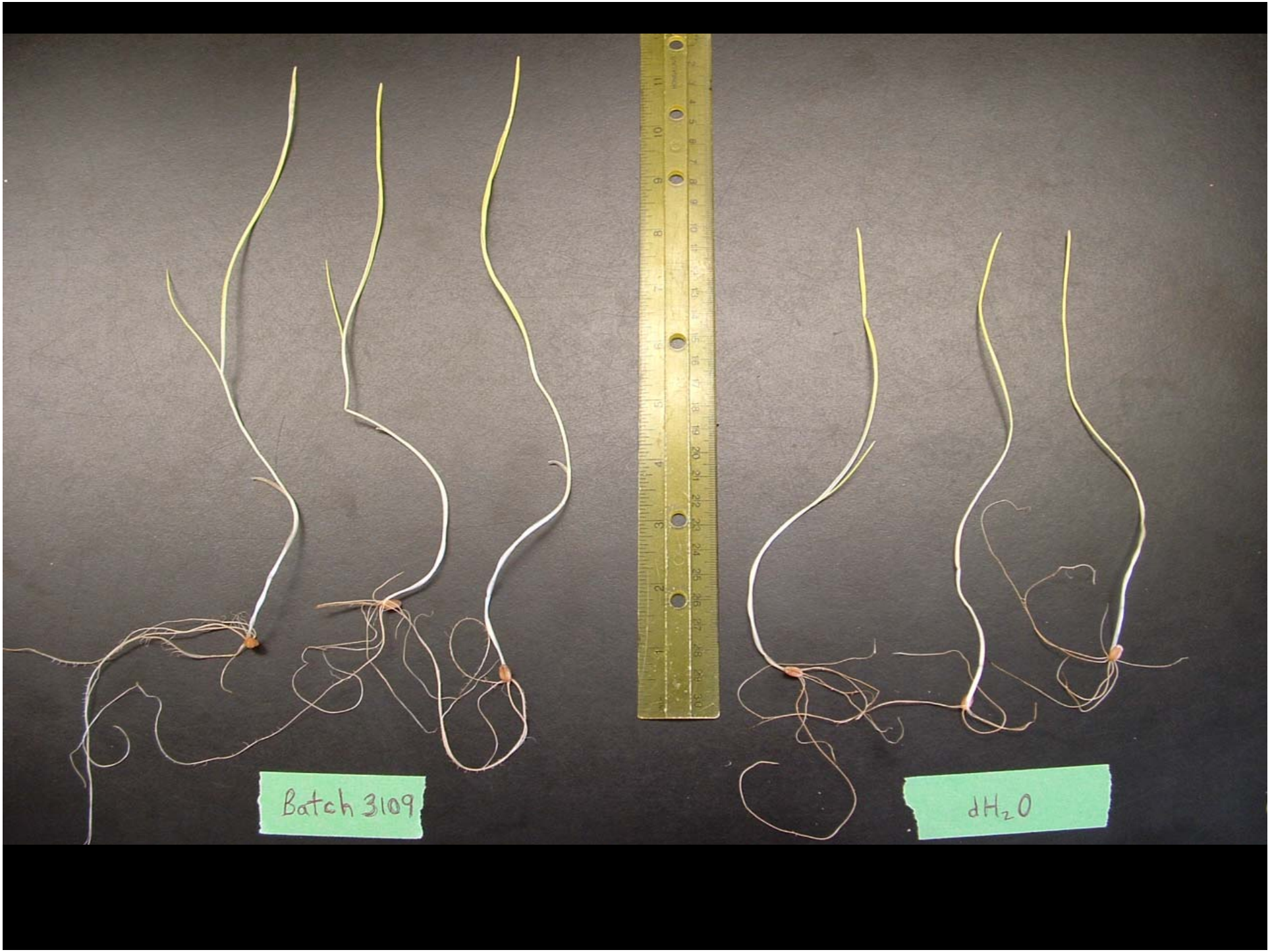
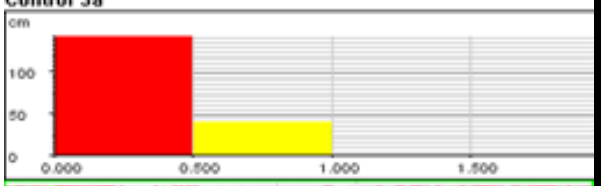
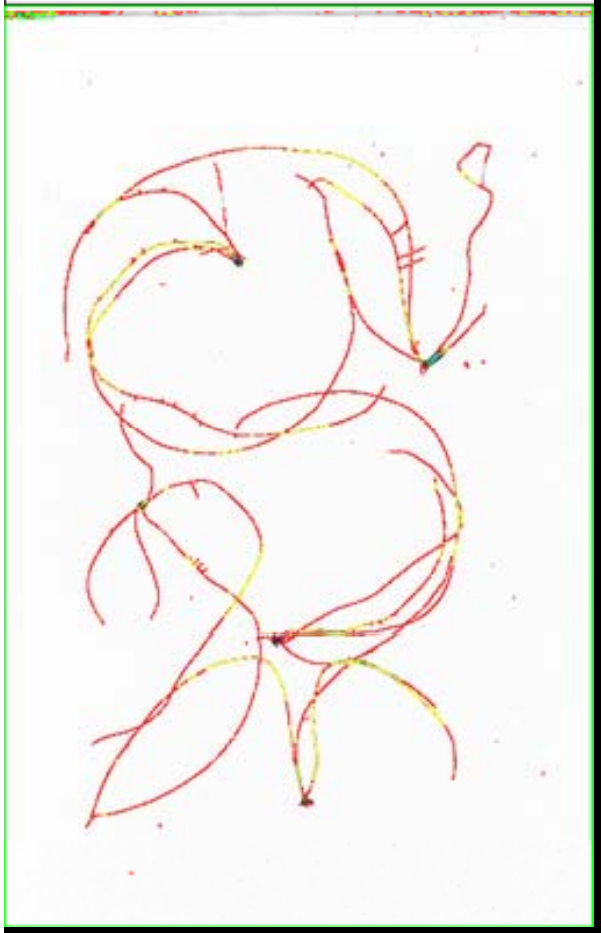

Batch 3109
dH2O

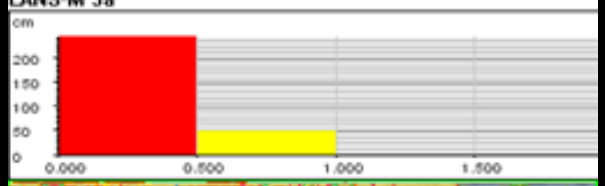
Figure 1. WinRhizo root scanner and associated computer software analyze plant roots for important characteristics of root physiology such as root surface area, root diameter, root volume, and the number of root tips. .

Control 3a

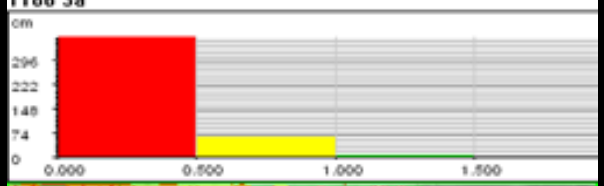




LANS-M 3a



1186 3a




Distilled Water
LANS-M 0.1x
Batch 5221 1g/L
07PHSAUPBAFRA01-03

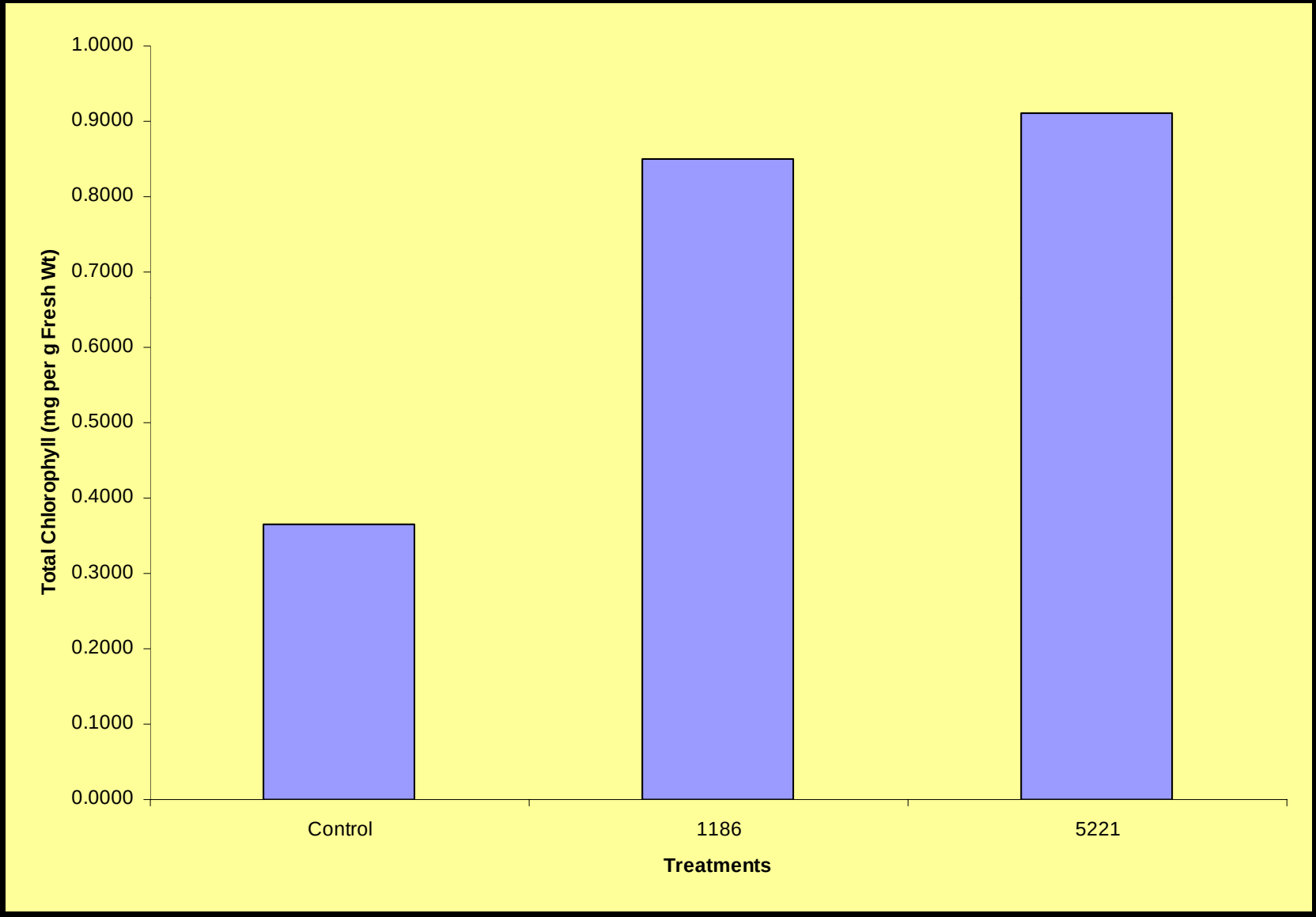
SSEP 5221

Arabidopsis
-4.5°C for
48 hours

Arabidopsis can Survive -2.6°C

Control

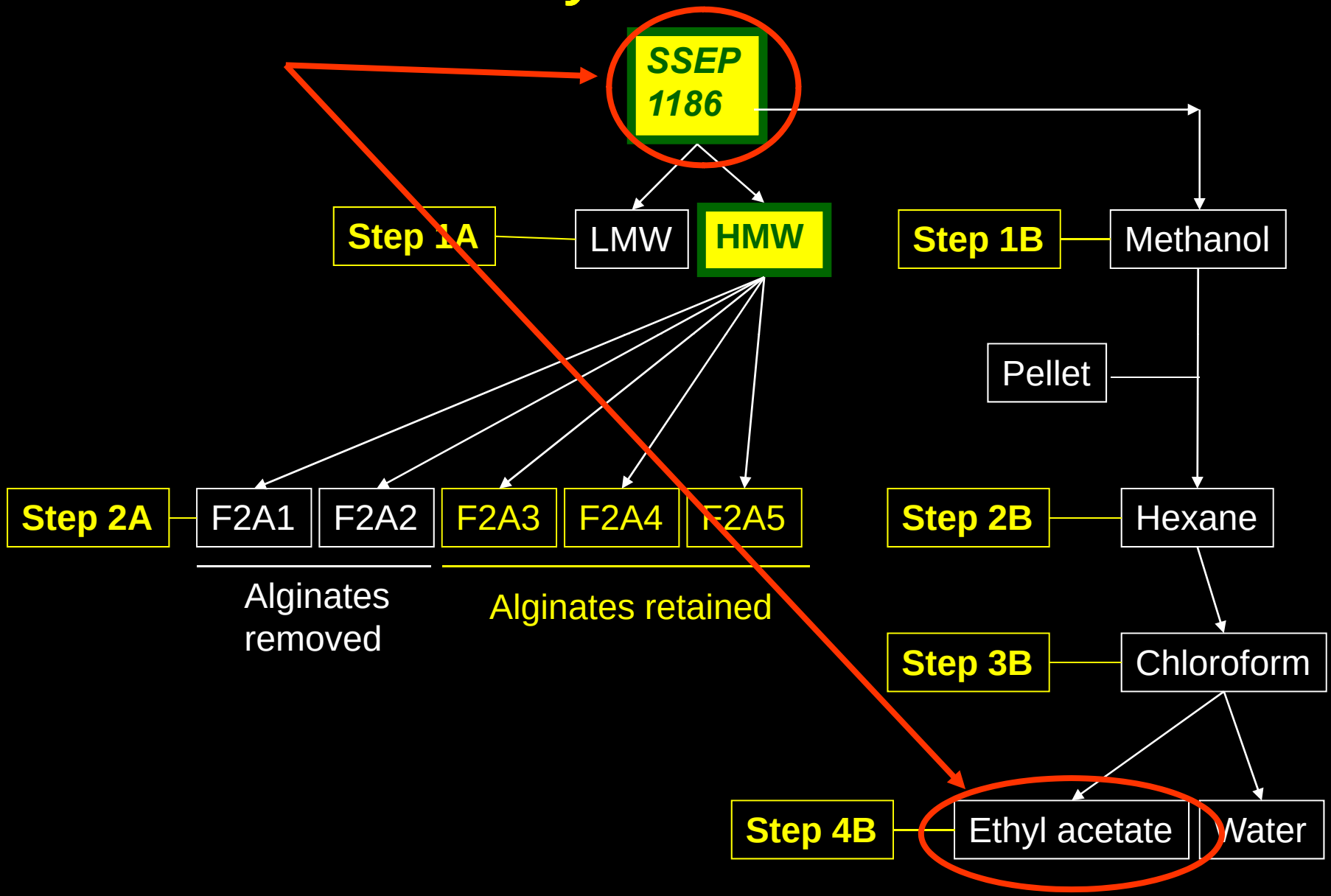
Total Chlorophyll Content after freezing

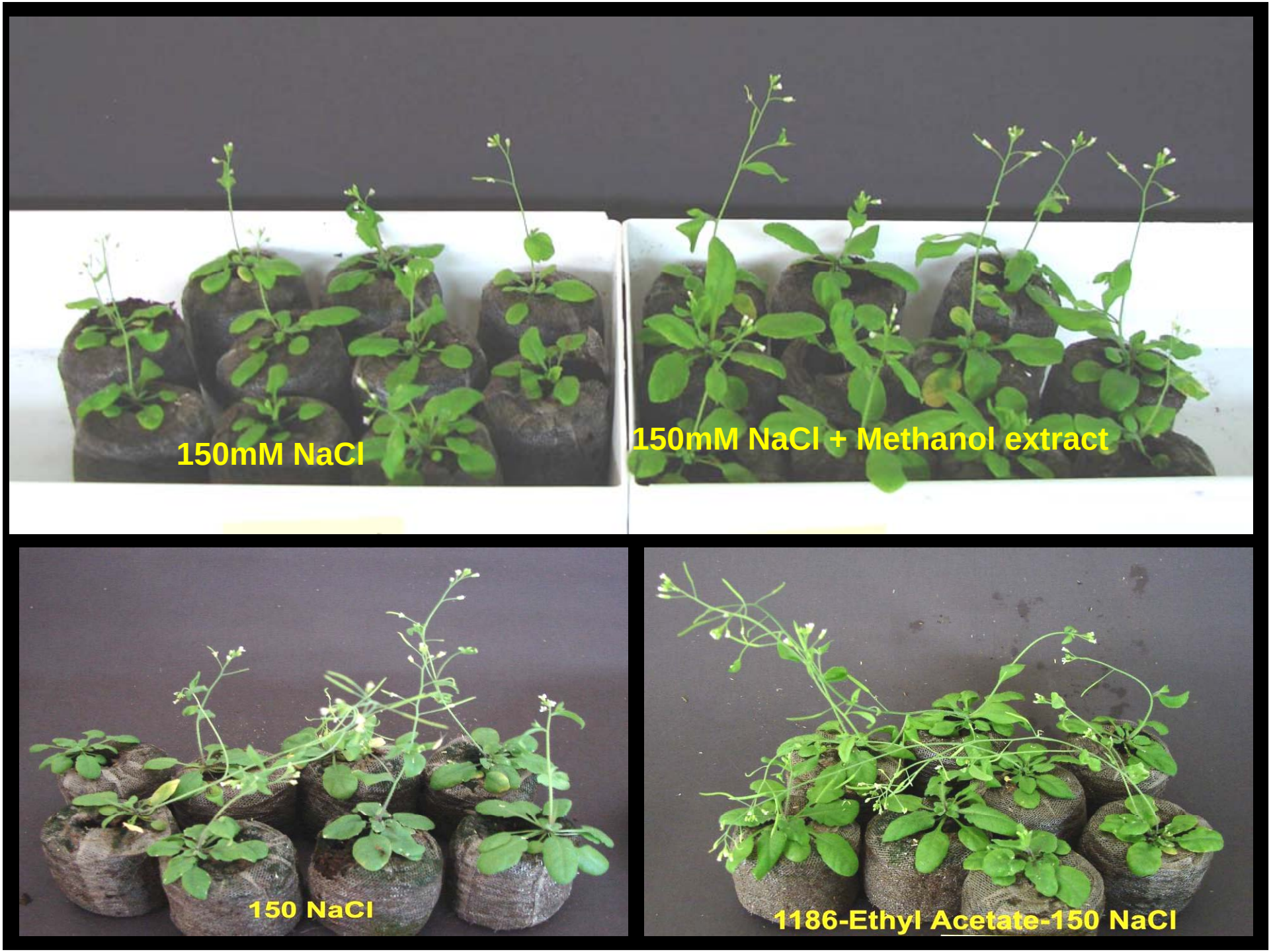


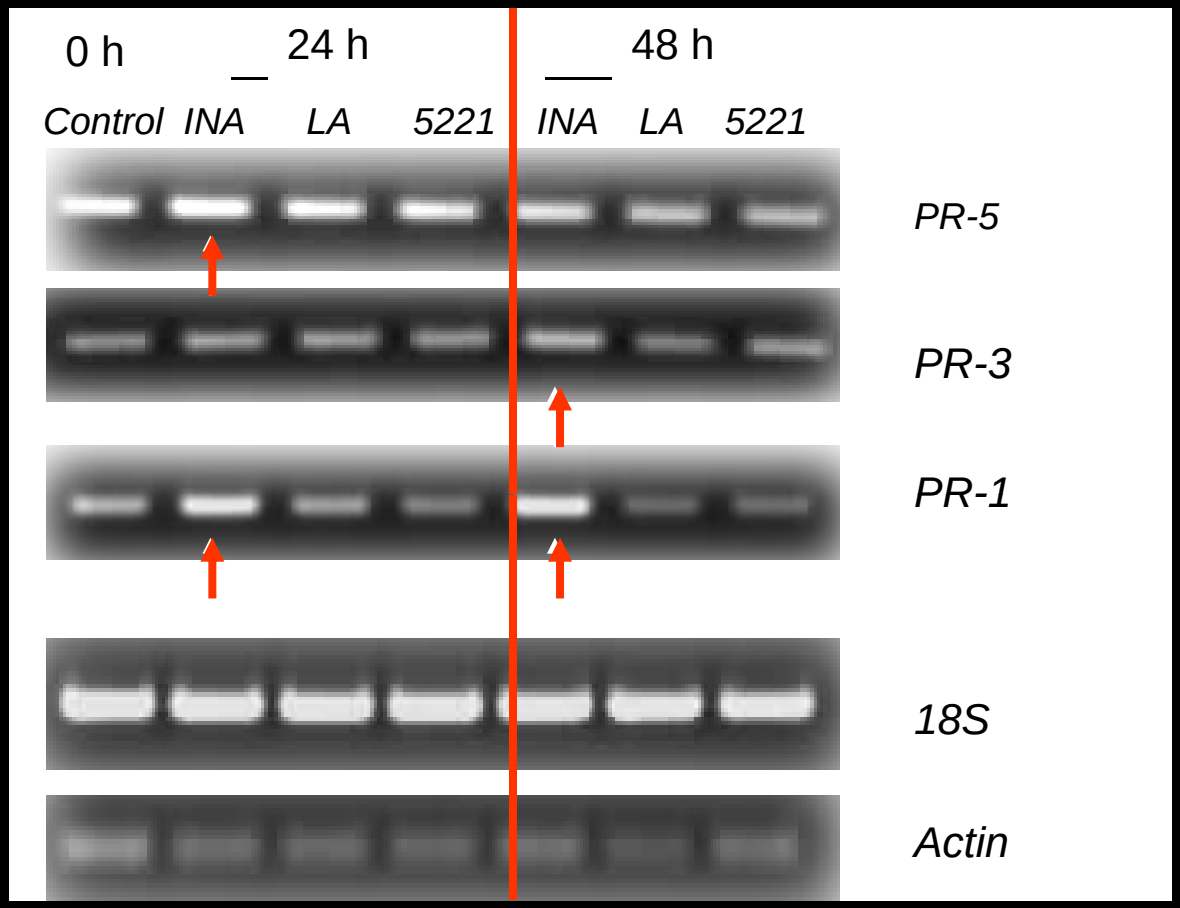
Enhanced Salinity Stress Resistance

150 mM NaCl

Enhanced Salinity Stress Resistance




150mM NaCl
150mM NaCl + Methanol extract
150 NaCl
1186-Ethyl Acetate-150 NaCl



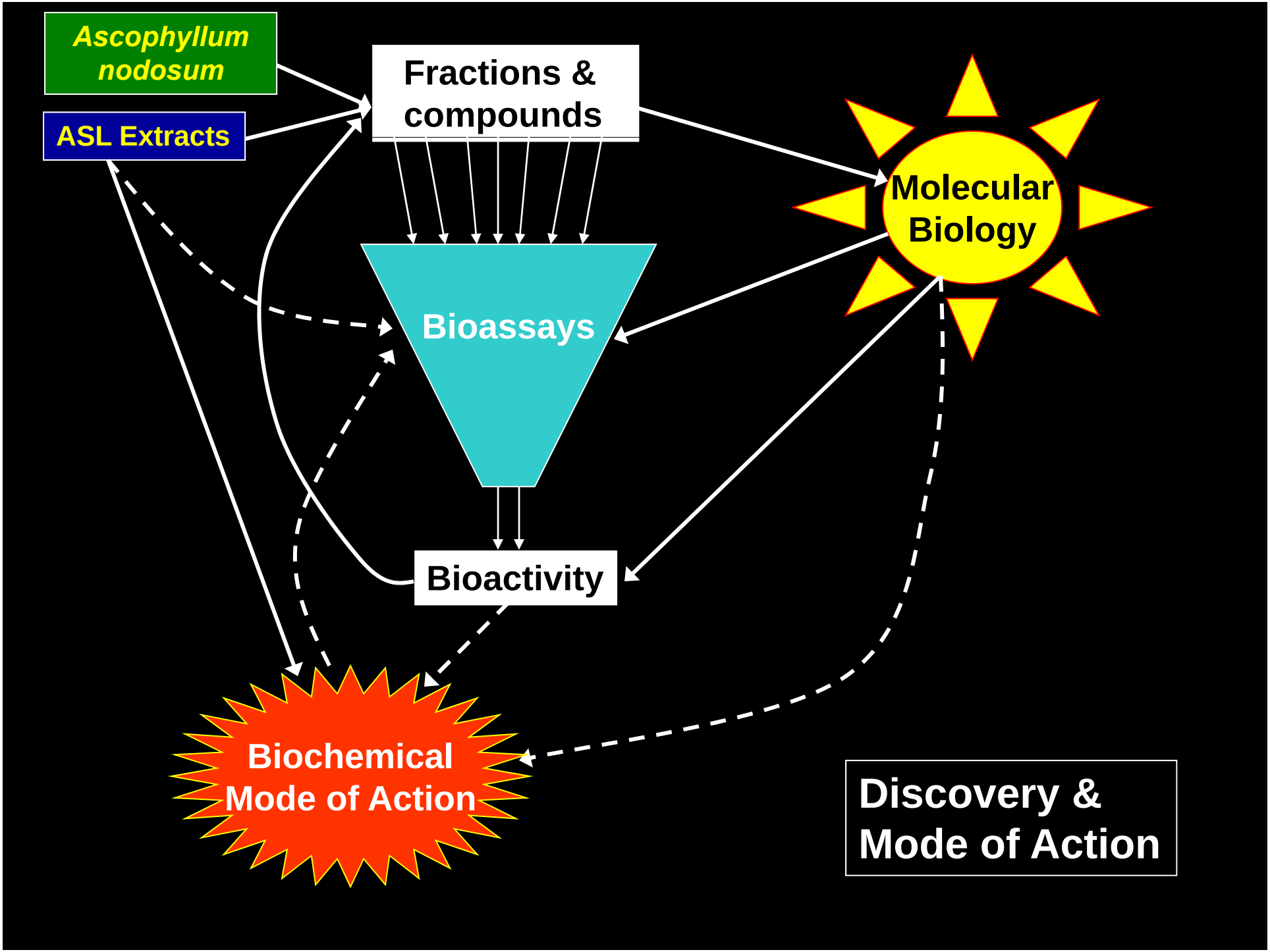
- INA = control treatment known to affect PR gene expression
- SSEP 5221 had no effect on PR1, PR3 or PR5 gene expression.

Disease (*Pseudomonas syringae*) development in *Arabidopsis* plants treated with SSEP 5221

Comparison of disease symptoms in leaves on plants treated with various concentrations of SSEP 5221

Results : *Plants harvested after four weeks*

Sinorhizobium meliloti was inoculated after 48 h of treatment


Ascophyllum nodosum
ASL Extracts
Fractions & compounds
Molecular Biology
Bioassays
Bioactivity
Biochemical Mode of Action
Discovery & Mode of Action


acadian™
Field Trials Program
Research field trials, coop trials, joint trials

Traditionally Responsive Crops

- Grapes
- Solanaceaes: Tomato, Peppers, Potato, Tobacco, Eggplant, others
- Apples, Strawberries, Cherries
- Stone fruits, Citrus

Other Responsive Crops

- Rice (India, US, Thailand, China)
- Watermelon (USSE, bioassays)
- Avocados (California)
- Cotton (US, International)
- Olives (Spain, Greece, Australia)
- Tropical crops (bananas)
- Almonds
- Strawberry through drip

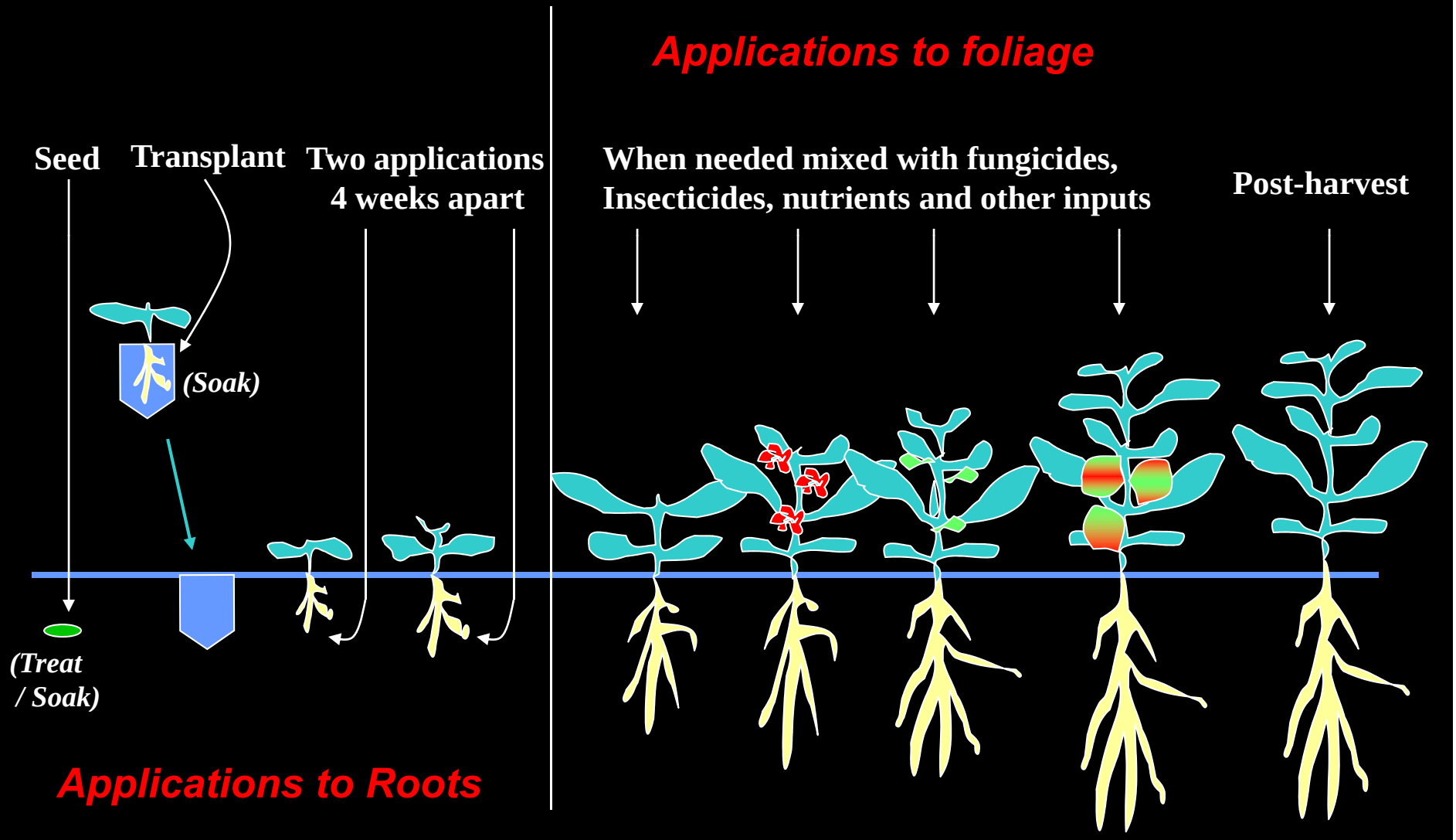
Developing Crops

- Legumes (alfalfa, beans)
- Field crops (cereals, soya)
- Grass seed production
- Blueberries

Novel Application Methods:
Rates and Timings

- Low rate applications (10-50% of our current recommendations)
  - Especially Asia and S. America
- High rate applications (50% to 100% more)
  - Developed countries: integrated programs
- Broadcast vs Tree-Row volume (TRV)
- Newer delivery systems (impregnation)
- Co-applications (fertigation)

Generalized Recommendations – Application Timings and Targets:



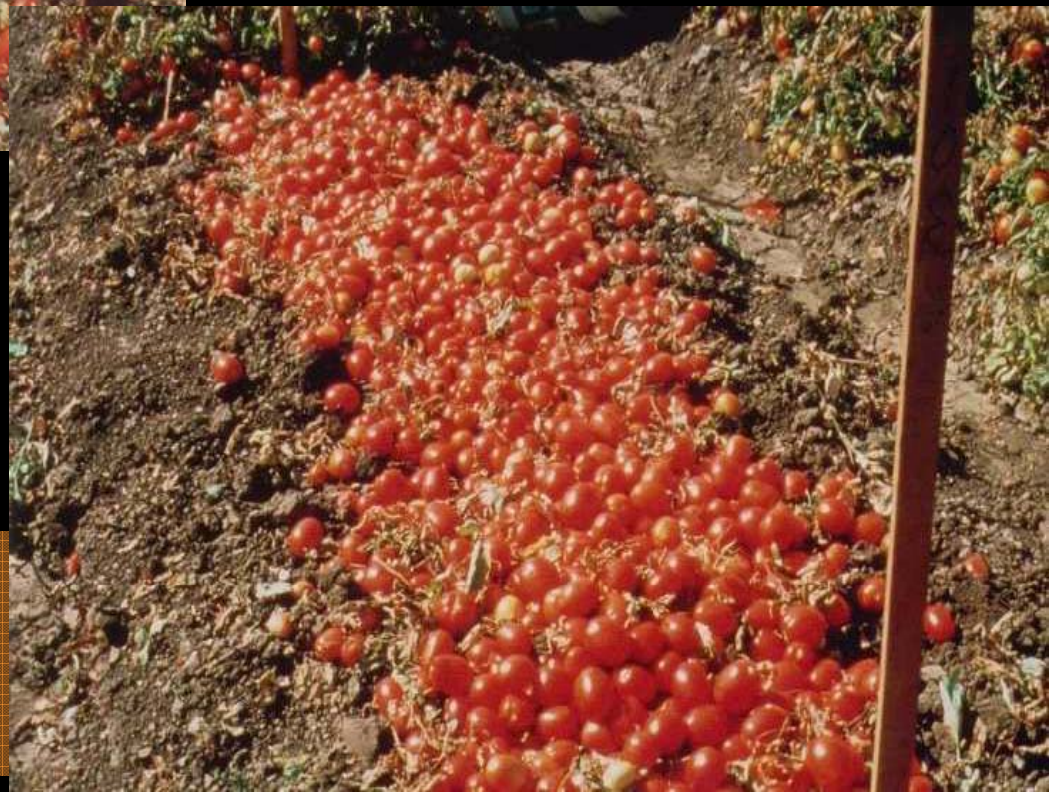
Growers juggling question

- Ball 1: Science
  - How many times should I apply?
  - Little-Often
- Ball 2: Economics
  - How many times can I afford to apply?
  - Consider ROI
- Ball 3: Practical
  - How many times will I actually apply?
  - Tank mixes, routines, weather, labour

Control

Plot: 3 x 10’

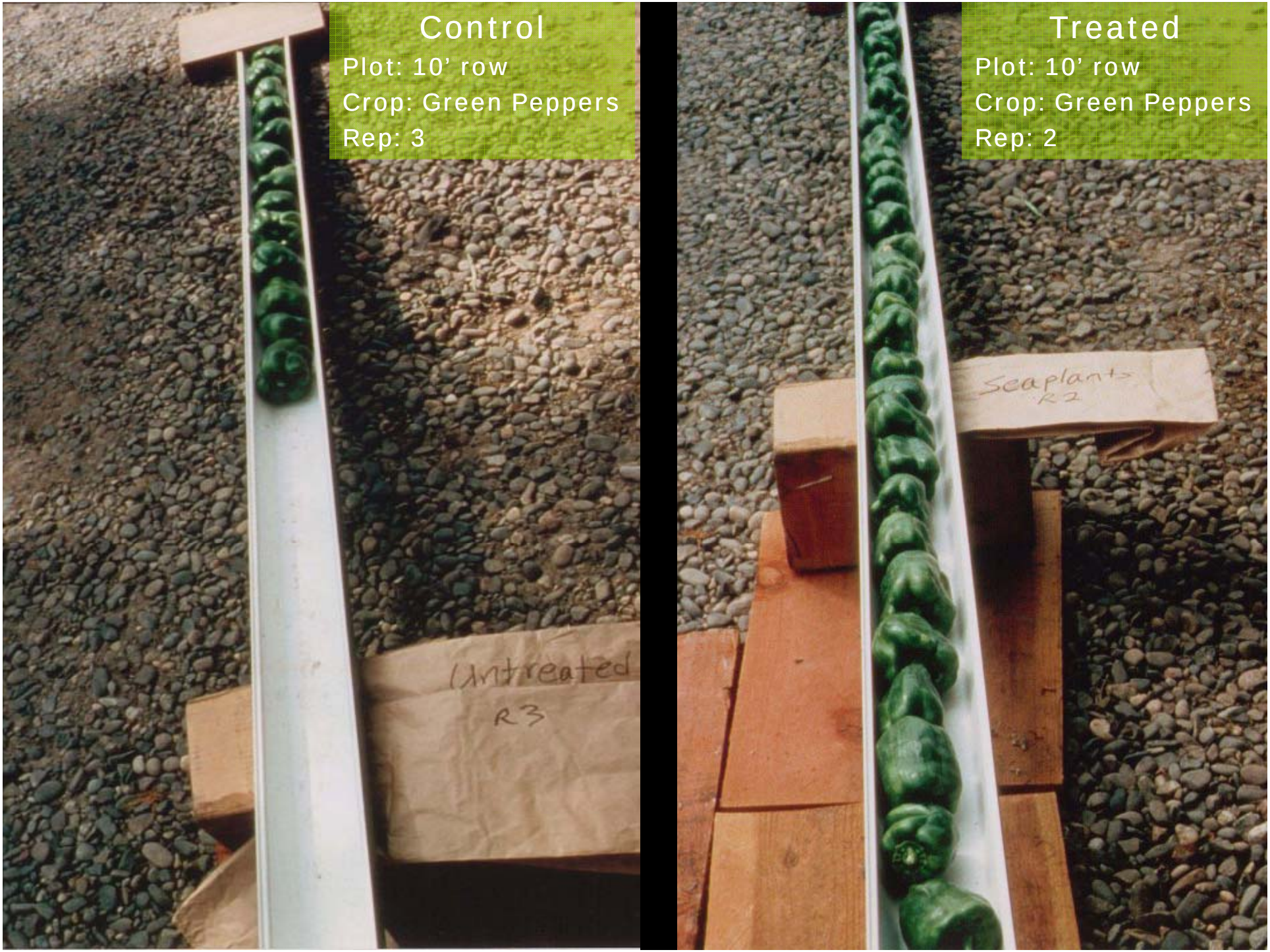
Crop: Processing tomatoes



Acadian

Plot: 3 x 10’

Crop: Processing tomatoes


Control
Plot: 10’ row
Crop: Green Peppers
Rep: 3
Untreated
R3
Treated
Plot: 10’ row
Crop: Green Peppers
Rep: 2
Seaplant
R2

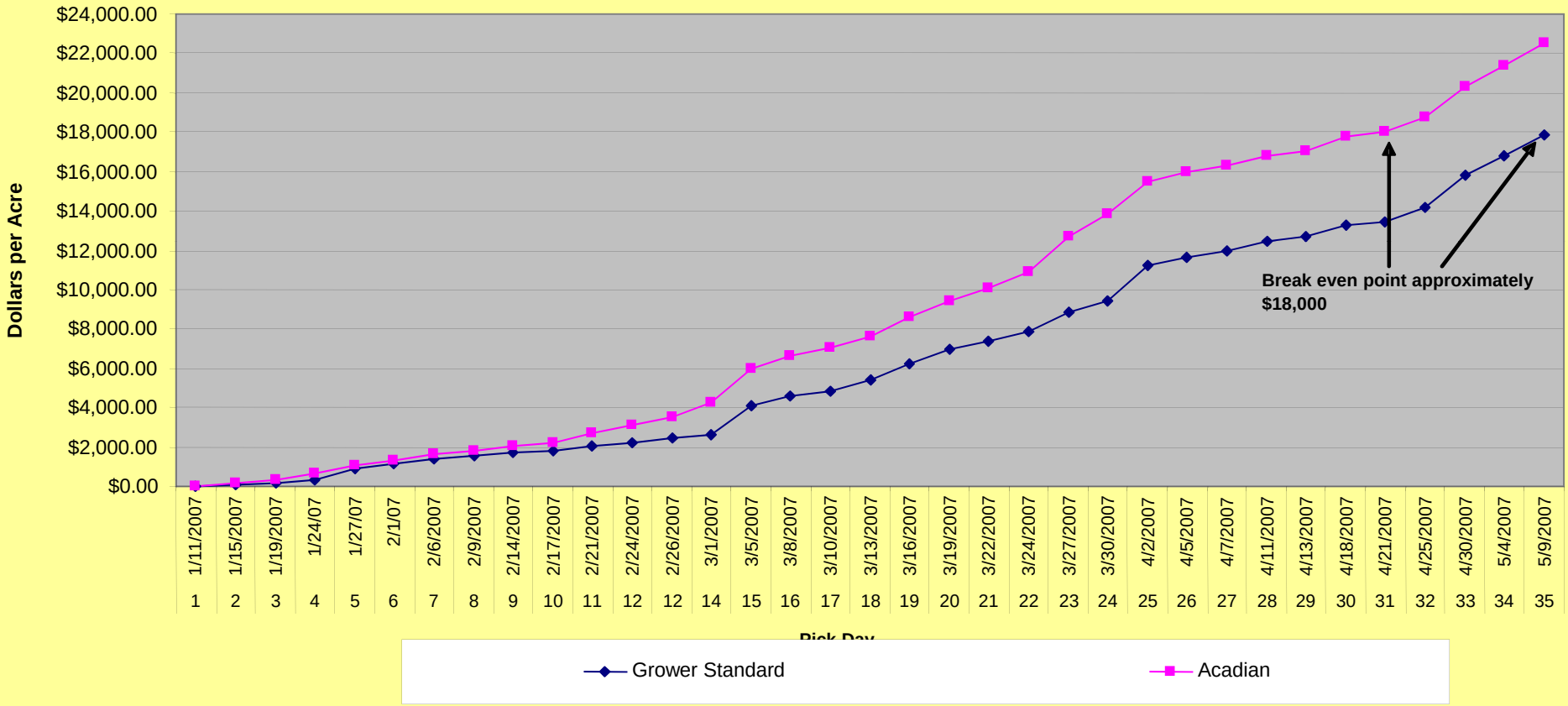

STANDARD
ACADIAN


2/1/07
Acadian
Treated
UTC
OfficeMax

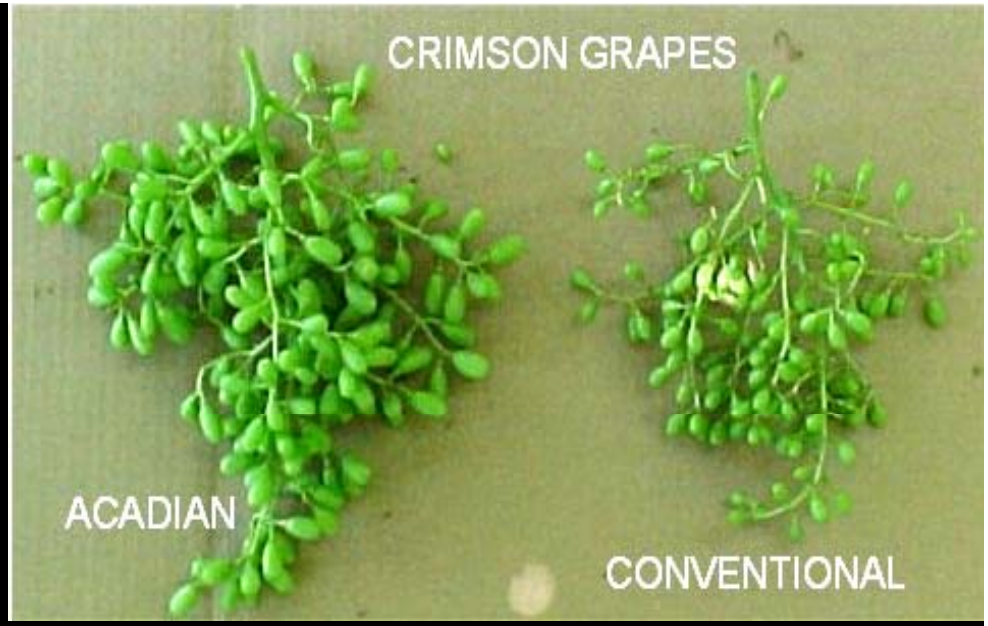

29 10:39AM

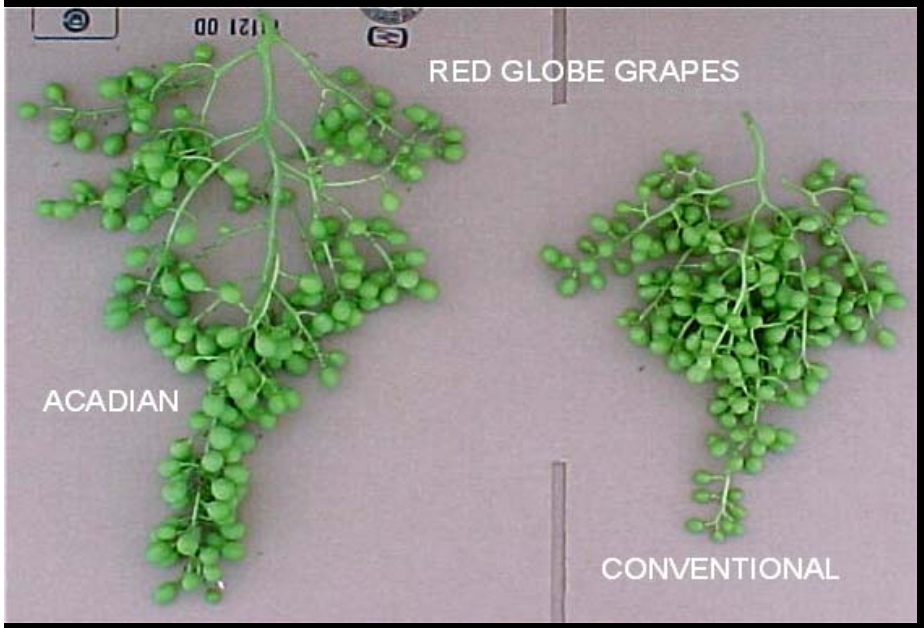

14 4:48PM

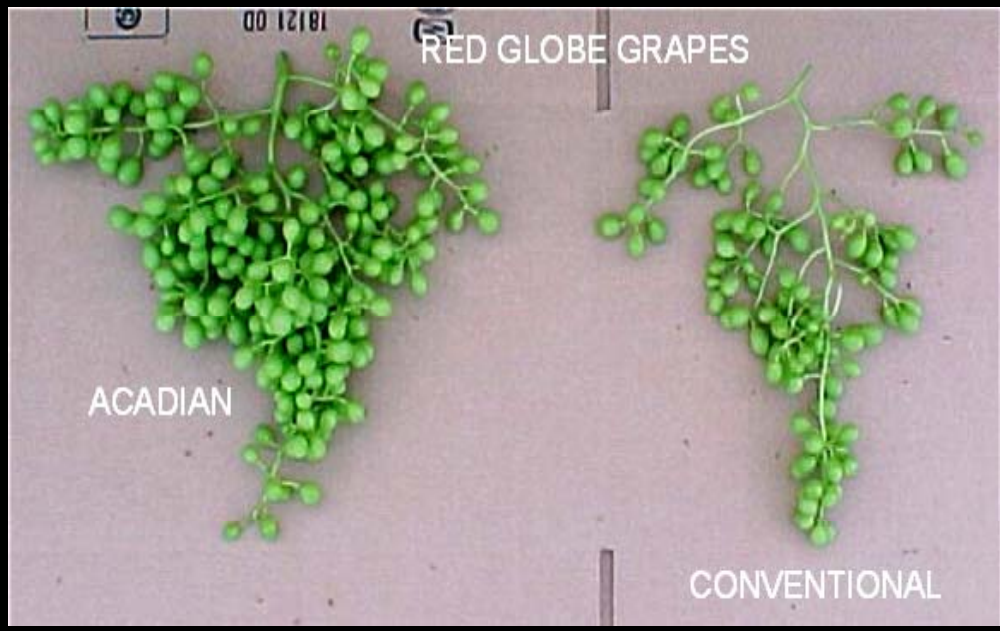
Chart 10: Acadian on Strawberries - Ventura County, Winter 2007 - Cumulative Marketable Production Net Return by Pick Day



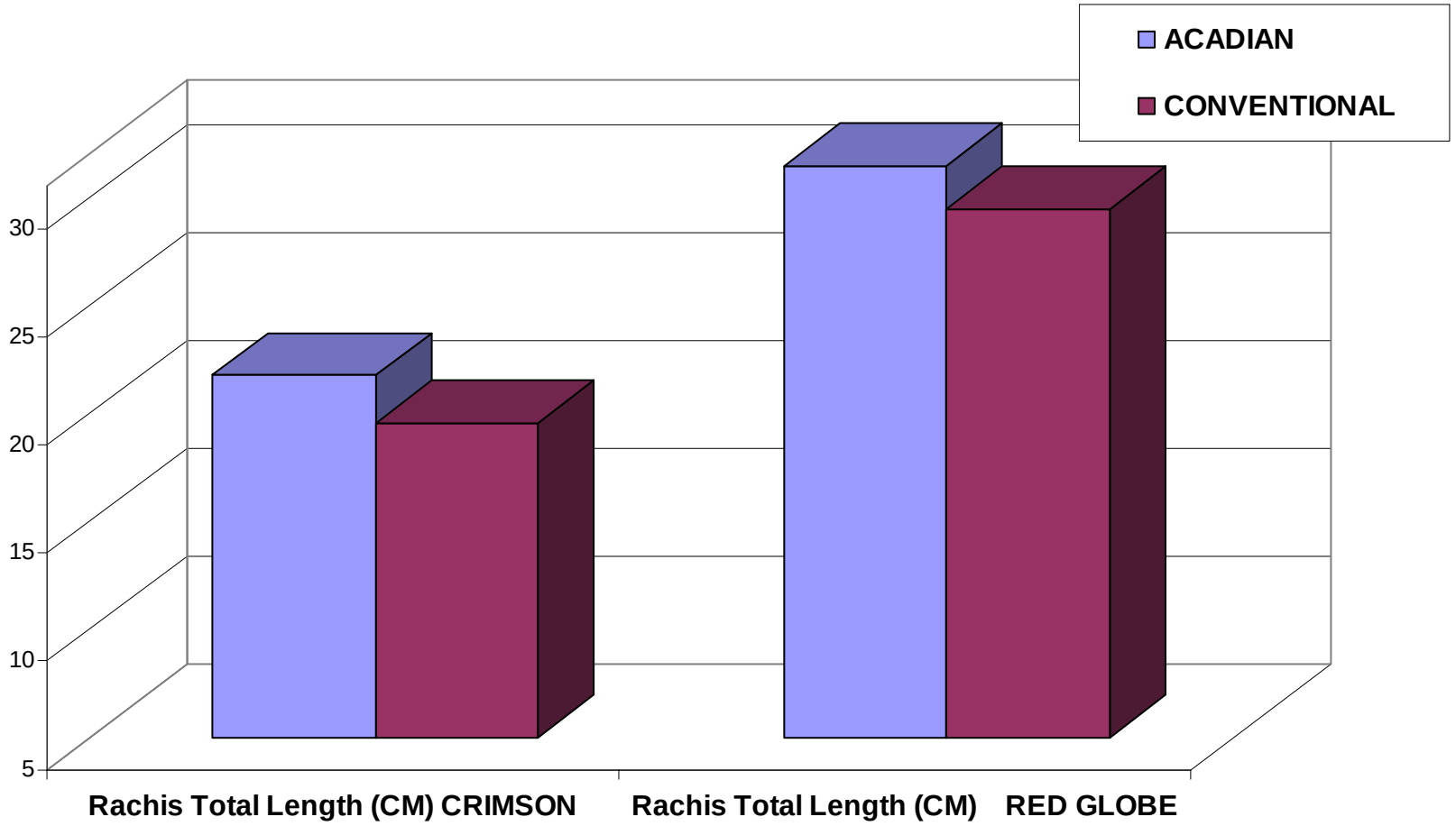

CRIMSON GRAPE BUNCHES
ACADIAN TREATED
CONVENTIONAL


CRIMSON GRAPES
ACADIAN
CONVENTIONAL


RED GLOBE GRAPES
ACADIAN
CONVENTIONAL


RED GLOBE GRAPES
ACADIAN
CONVENTIONAL

Effect Of Acadian, Soil-Applied Post Veraison On Rachis Length In CRIMSON and RED GLOBE Grapes, Fresno, CA. 2002

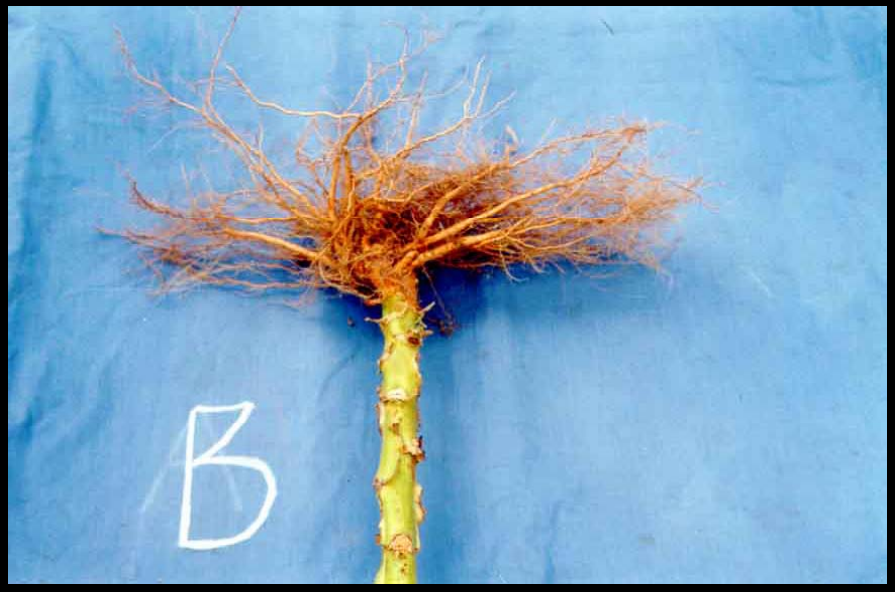


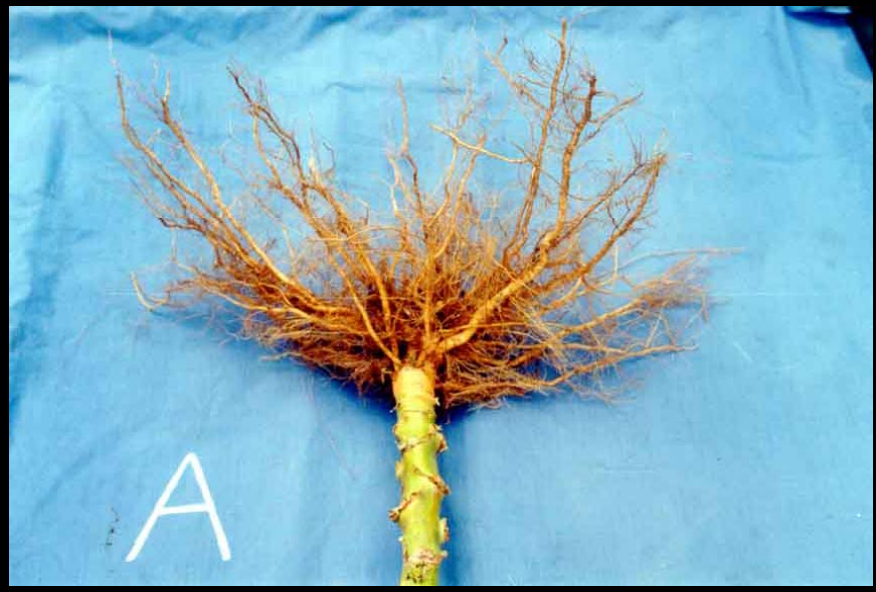

BIOVITA
ENRICH CROP PRODUCTION

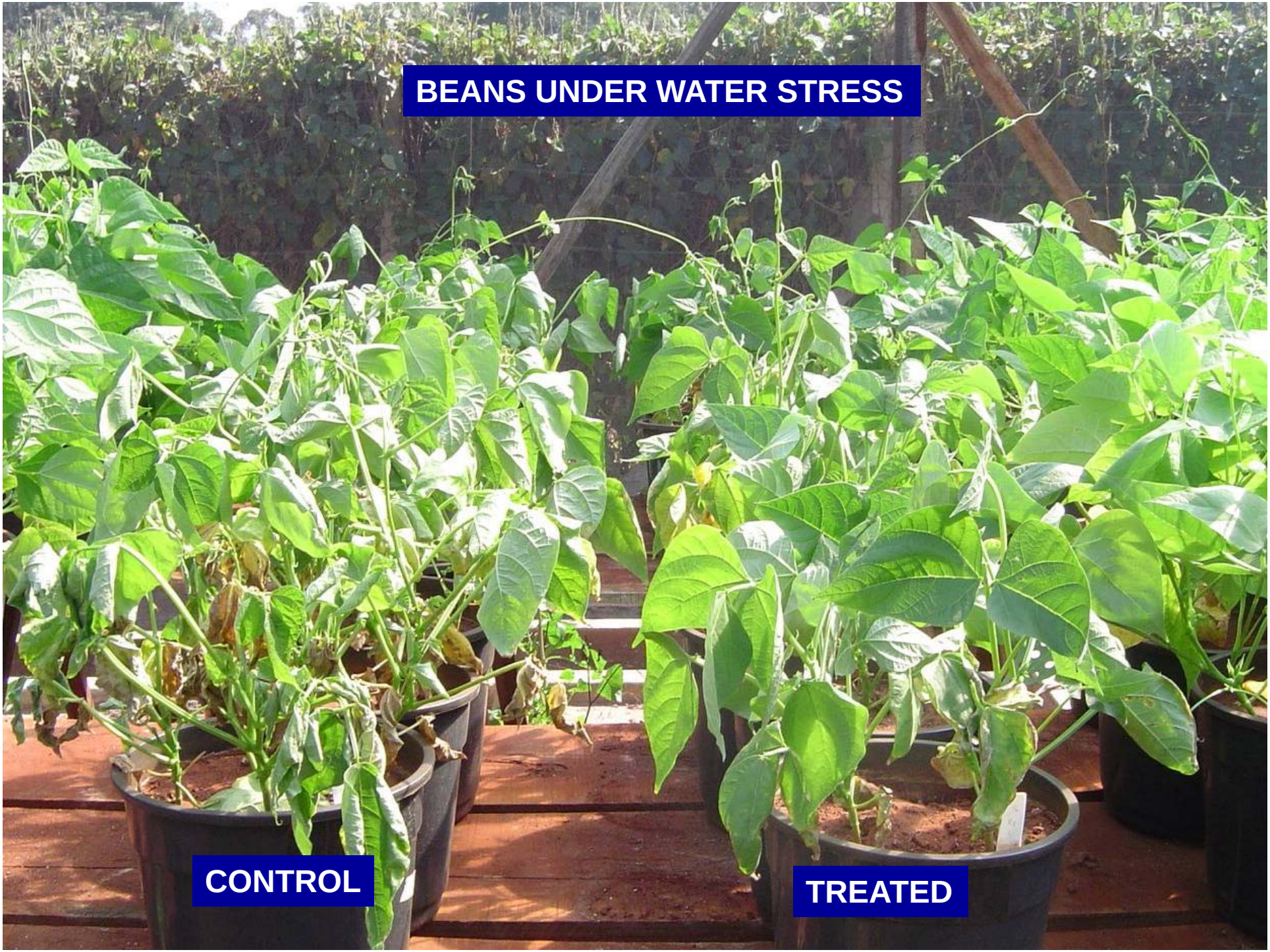
Tobacco

B: Control

A: Treated






BEANS UNDER WATER STRESS
CONTROL
TREATED

Benefits of *Ascophyllum*

Take Home Messages

- Benefits through foliar applications:
  - Improved plant nutrition, growth and development
  - Improved fruit quality and quantity
  - Improved efficiency of crop inputs
  - Enhanced disease, insect and nematode repression

Benefits of *Ascophyllum*

Take Home Messages

- Benefits through soil applications :
  - ***Stimulate plant beneficial microbes and increase soil suppressiveness to diseases***
  - ***Induce a direct SAR effect via the roots***
- Leads to better crop establishment, improved crop health and ultimately increased productivity plus profitability (to growers)

Benefits of *Ascophyllum*

Take Home Messages

- *Ascophyllum nodosum* extract is a general biostimulant
  - (vitamin-like effects)
  - Substantial research shows SAR benefits
- Can be used many times during the season
  - Foliar and/or soil applications
    - Stimulates growth and development at time of application
    - Can use often without toxicity problems

Benefits of *Ascophyllum* Take Home Messages

- Seaweed products can be made in different ways (e.g. species, processing and extraction)
  - May result in different activities.
- Identifying active ingredients in *Ascophyllum* extracts
  - Foot-printing molecular profiles of our products
- Connecting activities with specific plant responses
  - In controlled bioassays
  - In the field
- Delivering best-use application information to growers and end-users on ongoing basis


GRACIAS
Merci
Thank you