H475 - Environmental Requirements of Horticultural Plants - Spring - 2004

Instructor: Dr. Cecil Stushnoff, Shepardson 113b, 491-7110
Assistant: Todd Einhorn
Classroom: Shepardson 120, Lectures 11:00-12:15 AM
Office hours: T, TR, 9:15 -10:00

Text: None required.
Recommended reading references
Taiz and Zeiger, Plant Physiology, 1st, 2ndor 3rd edition
All journal article papers assigned in class

Course Objectives:

1. To facilitate integration of concepts pertaining to the impact of environmental factors on the growth and development of horticultural crops and other plants. To encourage in-depth study and application of special environmental conditions to achieve maximum growth and development of horticultural crops for commercial and/or avocational purposes.

2. To become familiar with terminology, definitions, and concepts connected with research on environmental physiology.

3. To encourage students to think about innovative applications of micro-environmental manipulations in the production of horticultural crops.

4. To create an awareness and to encourage discussion about the impact of global climatic change on the outdoor environment and on implications to agricultural productivity.

5. To promote an understanding of how research publications can further our appreciation of environmental physiology.

6. To conduct an experiment that examines the impact of an environmental stress on nutritional quality of a horticultural food crop; to collect, graph, and analyze data, and communicate the results verbally and in the form of a poster or power point presentation. Individual projects will be compiled as a class CD.

OR alternatively

7. To prepare an extension report with sufficient detail to enable the reader to optimize field production of a horticultural crop. The document must cover environmental management requirements that determine successful production. It should be based upon and should cite at least five published journal research papers and must extract graphic and /or tabular data based on water, temperature and light requirements. The final product should be in electronic format that can be compiled as a class CD.

Grades :

(1) **Three quizzes** Feb. 10 on water and salinity; March 11 on temperature; April 20 on light, UV-B, pollutants, free radical and antioxidants (100 points each) = 300

(2) **Responses** to literature reading assignment questions (100 points, 10 points each)

(3) **Research project or extension report** with a 10-minute oral presentation to the class. = 200 points. Students are encouraged to enter their posters in the University -wide undergraduate research poster competition. (50 point bonus)

The research project topic can be chosen from the project plan provided. These projects are short-term in nature and generally anticipated to provide results, but students are expected to be creative in adding or modifying the projects to explore special interests and add depth. Students are expected to prepare a written report that will include: (A) a brief literature review (3-5 references) with a hypothesis statement and objectives of the research, (B) materials and methods including an outline the experimental details, (C) results in graphs and tables, (D) discussion and conclusions, (E) literature cited.

The project consists of red and green cultivars of four leafy vegetables: lettuce, basil, kale and chard. Plants will be grown in the Plant Science greenhouse until Feb.23, when treatments will be started. Regimes that impose drought stress (dry-down), salinity stress, cold-stress, heat stress and low light intensity will be completed by spring break, March 15-19. Teams will harvest and weigh plants. Samples will be freeze dried during spring break. Total phenolics analyses will be conducted (two to three days for each team) after spring break.

Data collected must be analyzed and prepared in the form of a power point class presentation April 29, May 4, May 6. Guidance, facilities and equipment required can be coordinated through Todd Einhorn and Ann McSay. Brief reports on progress can be made to the class at regular intervals to keep all informed and to seek suggestions with problems.

The poster should contain:

(1) a title, investigators name and affiliation, a one paragraph abstract;
(2) a one or two paragraph literature review based on cited research journal papers, that introduce the reader to the importance of the problem and justifies why the work was done, and what approach was used to do the work;
(3) a materials and methods section that briefly, but concisely states how the work could be repeated by someone else;
(4) a presentation of results in the form of graphs, and/or tables, and photos;
(5) a discussion and conclusion of the significance of the results relative to previous knowledge and their potential practical or scientific impact.
(6) a few (2-3) references

Other requirements: Size: 4'x4'; easy to read from 4' away; title, text and visuals mounted on poster board or some other stiff background in an attractive display; printed in an easy to read font such as arial or CG Times using bold for headings, etc. For additional help and tips on designing posters visit the CTSS plotting services webpage: http://www.ctss.colostate.edu/plotting_services.asp 224 Weber bldg.

General Topic Outline

Introduction: research impact; communicating research;
Discussion of potential research projects
Concepts used in creative problem solving
Communication of research results

A. Water
- Physical and biochemical properties
- Water relations in plants and soils
- Control of key growth processes
- Water logging
- Drought
- Salinity

B. Temperature
- Plants and the thermal environment
- Temperature and plant adaptation
- Control of growth and biochemical reactions
- Dormancy
- Low temperature stresses
- High temperature stresses
- Managing the environment for horticultural production
- Protected environment production
- Frost and freeze protection

C. Light
- Energy and carbon
- Radiation and irradiance
- Leaf canopies
- Spectral distribution
- Intensity, duration, quality

D. UV-B and air pollutants
- Free radicals and antioxidants in plants and food

E. Antioxidants and health attributes of fruits and vegetables

Creative Thinking

The earliest creative thinker to leave records of his method was Socrates. Basically, people are lazy when it comes to thinking. Creative thinking is driven by a problem "a thorn in the mind". Irritation or incentive motivation is required to stimulate creative problem solving.

First necessity of creative problem solving: A problem that bothers us so much we must do something about it.

Second necessity of creative problem solving: We must state the problem in a manner that will enable us to both understand it clearly and to solve it.

Third necessity of creative problem solving: Preparation by assembly of the essential elements.

"Creativity consists in forming new combinations of images and ideas previously gathered and deposited in memory. Nothing can come of nothing; so if we have assembled no new raw materials, we can produce no new combinations" Joshua Reynolds. Furthermore, knowledge, ideas and facts must be organized and classified. A disorganized mind full of haphazard notions seldom leads to creative thinking.

Sources of raw materials

Our own past experience
Past experiences of others stored in library books and papers
By observing events happening around us
By studying situations that are like ours and have been solved
By conducting experiments
By discussing the problem with others, stimulating creative group output

Fourth necessity of creative problem solving: Choose suitable bits from our storehouse of raw material and assemble in a new combination that will solve the problem.

Fifth necessity of creative problem solving: Subject the proposed solution to trial to prove its validity. These steps can be stated in other ways, but the essence is: **"a methodical progression from a problem to a solution, from a thorn in the mind to a useful and usable solution"**

Helpful Hints

- Develop an ability to recognize a problem in the most general terms, then restate, analyze, and subdivide the problem

- Research is a creative problem solving activity. It is primarily a mental activity: creative thinking, followed by physical processes of investigation. Two key actions required for successful research are a keen sense of unbiased observation followed by careful reasoning or deduction.

- There are at least two distinct approaches to research: (a) an empirical approach where large numbers of experiments or observations are generated to form a basis for development of a theory (Baconian-Edisonian); (b) an approach whereby a theory is first formulated based on previous knowledge and is then tested by experiments to prove or disprove it (Artistotle-Bancroft).

- Organized group thinking to focus on a problem generally produces better results than the sum of accomplishments from the same individuals working independently.

- A systematic approach where bits of a large problem are solved with progressive restatements of the problem usually is more productive than attempting to hit a home run the first time at bat.

A summary guide to increase problem solving effectiveness

1. State and restate the problem until it is in terms that make the solution possible. This means subdividing it into smaller units that can be handled instead of tackling it all at once. Maybe available resources will permit solution of only a small part of a bigger problem.

2. Concentrate on a small area and learn everything there is to know. Add new factual material to assist progression to the next step.

3. Use a systematic methodical approach in collecting, sorting, and recording facts. Patents are awarded on the basis of dates of unique events recorded in a permanent notebook. Also a paper trail of facts learned from the library or experiments make sit easier to retrace and regroup when a step fails to work as predicted.

4. Find time to think. A few minutes of thinking about something else, even daydreaming may lead to an important idea that continuous concentration may not.

5. Seek a totally different point of view. Break the mold, employ a paradigm shift. Discuss with a colleague, read in a different field. A concept from physics may help solve a problem in horticulture by illuminating what may seem like a hopeless maize.

Proposed Schedule of Topics (subject to change as speakers are inserted into the schedule)		
Jan. 20 22	Introduction to course structure, creative problem solving, Water relations, soil/plant/atmosphere continuum (Todd Einhorn)	
27 29	Water stress, osmotic potential, measurement Drought stress	Problem set #1
Feb. 3 5	Salinity and ion toxicity (C. Stushnoff) Water logging, anoxia, hypoxia	Problem set# 2
Feb. 10 12	Quiz #1 on water, drought, salinity Temperature regulation of growth, development, and survival, measurement	
17 19	Chilling injury Ice nucleation	Problem set #3
24 26	Avoidance (supercooling) and tolerance mechanisms Cryopreservation of plant germplasm	Problem set # 4
Mar. 2 4	Woody plant dormancy and cold acclimation Frost protection, site selection	Problem set # 5
Mar. 9 11	Heat stress, global warming Quiz #2 on cold and warm temperature	Problem set # 6
Mar. 16-18	Spring recess	
23 25	Global climatic change Light – duration, intensity, quality	
30 April 1	Light – duration, intensity, quality UV-B	Problem set # 7
April 6 8	Pollutant effects on horticultural crops Free radicals	Problem set # 9
13 15	Antioxidants and nutrients in fruits and vegetables Antioxidants and nutrients in fruits and vegetables	Problem set # 10
20 22	Quiz #3 on global climatic change, light, UV-B, pollutants, free radicals, antioxidants Open for speaker catch up	
27 29	Open for speaker catch up Power point and poster presentations and discussion	
May 4 May 6	Power point and poster presentations and discussion Power point and poster presentations and discussion	
May 10-14	Final (Exempt unless desired by students to improve grade)	

The H475 Red/Green Research Project

Objective: To conduct a group research project that will test the response of four leafy vegetables to imposed drought stress, salinity stress, reduced light intensity, cool temperature and high temperature.

Hypothesis #1:
Red-pigmented leafy vegetable cultivars contain higher total phenolic content than green cultivars.

Hypothesis # 2: Red–pigmented cultivars will tolerate environmental stresses better than non-pigmented cultivars.

Hypotheses # 3, 4, 5, 6, 7 (assignment, 10 points, hand in as problem #1)

Materials and Methods: Two cultivars (one red, one green) for each of four leafy vegetables: leaf lettuce, basil, kale and chard will be grown for 6 weeks (Jan. 12 to Feb 22) in a commercial peat-light mix, in 4-inch pots under supplemental sodium vapor lights (18 hours) at ambient day temperature 63 F night temperature. Plants will be grown under a continuous fertilization program. Five stress treatments will be imposed Feb. 23 until Mar. 11 when they will be harvested, weighed fresh, freeze dried, and weighed dry. After spring break (March 18) samples will be extracted and analyzed for total phenolics using a spectrophotometric assay with Folin Ciocalteu reagent. Lettuce plants will be grown as control unstressed plants and subjected to all stresses. One other crop will be compared as stressed and unstressed control plants for each of the stress treatments outlined under experimental treatments. Three replicates of single plants will be used. Data will be collected on fresh weight, dry weight and total phenolics. Any other data students may wish to collect is welcome.

Experimental Treatments

1. **Control** – To the extent possible, plants will be grown under optimum moisture, temperature, osmolality and light for the entire growth period.
2. **Drought stress** will be imposed by subjecting treatment plants to dry-down cycles beginning Feb. 23. In this treatment watering will be suspended until the onset of morning wilt, at which time plants will be watered sufficiently to thoroughly wet the media, then suspended again until wilting recurs. This cycle is repeated until harvest. During dry-down plants can be weighed periodically to estimate moisture loss.
3. **Salt stress** will be imposed by watering with 50 mM NaCl for 6 days beginning Feb.23, then with 100 mM NaCl for 6 days and with 150 mM NaCl for 6 days, until harvest.
4. **Reduced light intensity** will be imposed Feb. 23 by providing overhead shade cloth until harvest.
5. **Low temperature stressed plants** will be moved to a growth chamber set at 45 F, Feb. 30 to Mar. 5 followed by 40 F until Mar. 11.
6. **High temperature stressed plants** will be moved to a growth cabinet set at 95 F, Feb 30 to Mar 11.

Timetable

Jan. 12 plant with pre-imbibed seed.
Feb. 23 begin treatments
March 11 harvest and weigh plants
March 12-18 freeze dry plants
March 22 March 30 Extract samples and conduct total phenolics assays
April 1–29 Analyze data, prepare graphs, power point presentations and posters.
April 29 May 4 Class presentations