

**PSS 8163 - Environmental Plant Physiology**

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# **PSS 8163 Environmental Plant Physiology Syllabus**

**A. Course Objectives:** Environmental plant physiology is concerned fundamentally with the physiology of crops as affected by ambient, but fluctuating environmental factors; physical, chemical, and biotic environments. It centers on developing an understanding of the relationships and interactions of species or crops within communities, and the physiological mechanisms involved in crop responses to environmental conditions and how plants/crops acquire the resources needed for establishing and building the canopies through the growth of various organs. The broad general topics include:

## **B. General Outline:**

### ***1. The environment of plants/crops (weeks 1 and 2)***

***Lecture:*** Introduction and overview of the course. The factors that limit crop productivity will be discussed. Climatic, seasonal and diurnal trends including extremes in weather such as temperatures (soil, air, leaf or canopy temperatures and their interrelationships), radiation (global, photosynthetically active radiation (PAR), diffuse radiation including reflectance from soil, canopies and leaves), rainfall, atmospheric carbon dioxide (diurnal, and seasonal and peep through the centuries), minerals such as nitrogen and potassium (leaf or canopy levels), and others such as ozone and UV-B radiation etc. will be presented. Also, the sources of this information will also be explored.

***Lab:*** The instrumentation, methodologies and principles involved in measuring the environmental factors will be discussed with hands-on-experience with instrumentation (The students will be taught the type of instruments used: the standard weather station instrumentation plus the other instruments used to monitor the environmental variables such as anemometers, radiometers and radiation sensors, thermocouples, infrared thermometers etc.).

***Exam 1:*** Accounts 20% of the total.

### ***2. Photosynthesis and respiration (weeks 3 to 5)***

***Lecture:*** As photosynthesis is obviously the basis of all life on earth and the capture of carbon from the atmosphere, understanding photosynthetic mechanisms and principles as affected by environmental factors is essential for crop management strategies. The primary focus will be on leaf and canopy level photosynthetic processes. Cellular and biochemical aspects will be referenced only as these mechanisms relate to crop responses to the environment. Crop photosynthetic responses to a range of temperature, rainfall (irrigation), light intensity, ultraviolet-B radiation, carbon dioxide concentration and mineral nutrition will be discussed. Seasonal trends in photosynthetic capacity and acclimation, and feedback inhibition as affected by source/sink relationships will be covered. The

influence and mechanisms of various pollutants on photosynthesis will also be presented. Also, management practices such as growth-regulator applications and row-spacings etc. will be covered as they affect photosynthesis directly or indirectly through canopy development.

The influence of environmental factors (light and carbon dioxide through substrate availability, salinity and water stress, nutrient supply, growing conditions such as flooding, hypoxic and anoxic soil conditions on respiration of various organs and whole canopies will be discussed. The intricate relationships between respiration and growth and carbon balance will be presented.

Emphasis will be placed on the importance and limitations of single leaf vs. canopy, short-term vs. long-term measurements and performance of crops to various environmental factors as we cannot derive growth rates of canopies from single leaves or short-term measurements.

**Lab:** The tools, techniques and the principles involved in measuring leaf and canopy photosynthesis and respiration will be discussed. Special emphasis will be placed on leaf-level instrumentation (PAR sensors, porometers, portable photosynthetic systems (LI-COR 6400), and canopy-level tools and instrumentation (the SPAR units and associated instruments such infrared gas analyzers, calibration methods, flow meters, rotometers, automatic data acquisition systems, pressure chambers etc.).

**Exam 2:** Accounts 20% of the total.

**3. *Canopy development, yield and dry matter allocation (various facets of growth and development of plants) (week 6 to 9)***

Growth and development are the essence of crop production. Plant development and growth plays a pivotal role in crop production systems, controlling the production rate of new leaves, the total number of leaves produced, the duration of leaf area expansion of individual leaves and thus the overall light intercepting canopies, the extension rates of stems and internodes and roots distribution, branching, number and thus establishing the water and nutrient uptake effectiveness, the development and initiation of various facets of organs, and the mass accretion of various organs and whole canopies thus establishing the overall plant productivity and usually the economic productivity.

All the above growth and developmental processes are being governed by environment and management factors. Description of various crop growth and development of major crops and the control mechanisms will be presented. The importance of temperature (air and canopies), photoperiod, and vernalization on flowering will be presented. The concept of source-sink relationships on crop development will be thoroughly discussed. The effects of water, nutrients including carbon, and other environmental factors will be presented using phytomer

concepts. The influence of environment on roots, fruits, seed and fiber development will also be presented. Crop development and its relationship to crop yield and yield components will be presented. Crop adaptations to various stresses will also be discussed.

**Lab:** The growth indices of various organs and crop developmental stages and the principles involved in developing those indices will be demonstrated.

**Exam 3:** Accounts 20% of the total.

4. ***Scaling from organs to canopy to ecosystems (Modeling methodologies) (week 10 to 11)***

Having discussed the gas exchange and growth indices as affected by environment and management factors, it is essential for the student to understand the limitations of scaling up from individual leaf physiological processes (photosynthesis, respiration, water-use and transpiration) to canopies and finally to crop community. Similarly, the student should comprehend the development and growth of individual organs on the plant and how these relate to one another (intra-plant) and to the overall community-level productivity. The complications and complexities of scaling from single leaf processes to canopy and communities, from single organs to canopy and single stresses to multiple stresses will be presented using modeling approaches. Modeling methodologies and the concepts of putting together the various processes will be presented to understand the performance of the crops in the field.

**Lab:** Several examples will be provided to demonstrate scaling up from organs to canopies, single leaves to canopies and canopies to communities. Crop models will be used to study the influence of environmental and management strategies on crop performance

**Exam 4:** Accounts 30% of the total.

5. ***General discussion (week 12)***

**Lecture:** General discussion, anything that relates the course material involving group discussions will be performed.

6. ***Special topics***

**1. Modeling plant growth regulators**

We will explore how to model plant growth regulators or other chemical that are being frequently being used in row crop agriculture. We will use Mepiquat chloride (PIX) an example.

## **2. Environmental plant physiology and remote sensing**

We will explore the interrelationships between plant physiology and remote sensing.

**Attendance and classroom discussion participation:** 10% of the total.

### **Books:**

Crops and Environmental Change, An Introduction to Effects of Global Warming, Increasing Atmospheric CO<sub>2</sub>, and O<sub>3</sub> concentrations, and Soil Salinization on Crop Physiology and Yield. 2005. S. G. Pritchard and J. S. Amthor, Food Products Press, New York, USA, pp. 421.

Crop Responses to the Environment. 2001. A. E. Hall. CRC Press. Boca Raton, Florida, USA, 232pp.

Climate Change and Global Crop Productivity. 2000. K. R. Reddy and H. F. Hodges (Eds.). CAB International, UK (21 Chapters), 472pp.

Feeding the Ten Billions: Plants and Population Growth. 1998. L. T. Evans. Cambridge University Press, pp. 247.

Plant Physiological Ecology. 1998. Lambers, H., F. S. Chaplin III, and T. L. Pons, Springer, pp. 540.

Agricultural Systems Modeling and Simulation. 1998. R. M. Peart and R. B. Curry (Eds.), Marcel Dekker, Inc., pp. 696.

Carbon dioxide, populations and communities, 1996. C. Konner and F. A. Bazzaz (eds.), Academic Press, published in their Physiological Ecology Series.

Technological Trajectories and Human Environment. 1997. Ed. By J. H. Ausubel and H. D. Langford. National Academy of Sciences, pp. 250.

Global climate change and agricultural production: direct and indirect effects of changing hydrological, pedological and plant physiological processes, 1996. F. A. Bazzaz and W. Sombroek (eds.), FAO of UN and John Wiley & Sons.

Carbon dioxide and terrestrial ecosystems. 1996. G. W. Kooch and H. A. Mooney (eds.), Academic Press, published in their Physiological Ecology Series.

Adapting to climate change: an international perspective. 1996. J. B. Smith. Springer-Verlag, New York, NY.

Plant Physiology, 1998. L. Taiz and E. Zeiger. Sinauer Associates, Inc., Publishers, pp. 792.

***Physiological Plant Ecology. Larcher, W. 1995. Springer, pp. 506.***

Water relations of plants and Soils. 1995. Kramer, P. J. and J. S. Boyer, Academic Press, pp. 495.

Measuring the water status of plants and soils. 1995. Boyer, J. S. Academic Press, pp. 178.

Handbook of Plant and Crop Physiology. 1995. Ed. By M. Pressarakli, Marcel Dekker, Inc. pp. 1004.

Food, Climate, and Carbon Dioxide - The Global Environment and World Food Production. 1995. Sylvan H. Wittwer, CRC Press, New York, NY.

Physiology and determination of crop yields. 1994. Boote, K. J., J. M. Bennet, T. R. Sinclair, and G. M. Paulsen. ASA/CSSA/SSSA publication, pp. 601.

Economic issues in global climate change agriculture, forestry, and natural resources. J. M. Reilly. 1992. Westview Press, Boulder, Co.

Modeling Crop Photosynthesis- From Biochemistry to Canopy. 1991. Ed. By K. J. Boote and R. S. Loomis. CSSA Special Publication, pp. 140.

Stress Responses in Plants: Adaptation and Acclimation Mechanisms. 1990. Ed. by R. G. Alscher and J. R. Cumming, Wiley-Liss, pp. 407.

Climate Change and Plant Genetic Resources. 1990. M. T. Jackson. Belhaven Press, London, UK.

Plant Canopies: Their Growth, Form and Function. 1989. G. Russel, B. Marshall, and P. G. Jarvis. Cambridge University Press, pp. 178.

Plant Growth Modeling for Resource management, Vol 1. Current Models and Methods, 1987. Ed. By K. Wisol and J. D. Hesketh. CRC Press, pp. 170.

Plant Growth Modeling for Resource management, Vol II. Quantifying Plant Processes. 1987. Ed. By K. Wisol and J. D. Hesketh. CRC Press, pp. 178.

Physiology of Cell Expansion During Plant Growth. 1987. D. J. Cosgrove and D. P. Knievel (Eds.). American Society of Plant Physiologists, pp. 318.

Control Mechanisms in Plant Development. 1970. A. W. Galston and P. J. Davies. Prentice-Hall, Inc., pp. 184.

Also, there are a few chapters in some society publications dealing with either specific processes or crops.

- a. Advances in carbon dioxide effects research. 1997. ASA Special Publication. Madison, WI.
- b. Climate change and agriculture: analysis of potential international impacts. 1995. ASA Special Publication no. 59, Madison, WI.
- c. Greenhouse: coping with climate change. 1996. CSIRO, Australia.

# PSS 8163 – Environmental Plant Physiology - Course Outline

## **Chapter 1: The Environment of Plants and/Crops**

1. Atmospheric carbon dioxide
2. Solar radiation
3. Temperature (Including extremes)
4. Water
5. Wind
6. Nutrients
7. Other factors such as Ozone, UV-B radiation etc.
8. Plant growth regulators
9. The facilities and tools

## **Chapter 2: Photosynthesis and Respiration**

1. Photosynthesis and the environment -  
The Environmental productivity (EPI) concept
2. The photosynthesis - The EPI concept - Species variability
3. Photosynthesis and Aging process
4. Respiration

## **Chapter 3: Canopy development, yield, and dry matter allocation (various facets of growth and development of plants)**

1. Crop growth and development - Phenology
2. Crop growth and development -  
Growth of various organs and whole plants

## **Chapter 4: Scaling of processes from organs to canopies to ecosystems (modeling methodologies)**

1. The cotton simulation model, GOSSYM

## **Chapter 5: Special topics**

1. Plant growth regulators - PIX or Mepiquat chloride
2. Remote sensing and environmental plant physiology