## Acknowledgement

UBC’s Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xwməθkwəy̓əm (Musqueam) people. The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on in their culture, history, and traditions from one generation to the next on this site.

## Course Information

Ongoing climate change causes unprecedented challenges for agriculture in Canada and globally. The modern farmer requires advanced knowledge about plant stress physiology to avoid losses in crop production and quality. But exactly how much water does a plant need to grow satisfactorily? A very common, yet very difficult question to answer. This course will provide an advanced understanding of the physiological mechanisms and biophysical principles that govern plant-water relations and hydration status. Plant water requirements will be discussed in the context of plant performance and survival. Traditional and cutting-edge techniques will be presented and explained that are currently used to monitor plant-water relations in laboratory and field conditions. This conceptual knowledge will provide the foundation for developing precision irrigation practices that promote water savings and sustainable agriculture.

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| --- | --- | --- |
| **Course Title** | **Course Code Number** | **Credit Value** |
| **Plant-Water Relations for Sustainable Agriculture** | 405 | 3 |

### Prerequisites

One of APBI 210, BIOL210

## Contacts

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| **Course Instructor(s)** | **Contact Details** | **Office Location** | **Office Hours** |
| Dr. Thorsten Knipfer | Email: [thorsten.knipfer@ubc.ca](mailto:thorsten.knipfer@ubc.ca)  I will respond to emails within working hours 9am to 5pm Monday to Friday. | MacMillan 321 | By appointment |
| Teaching Assistant: Steven Bristow | Email:  [sbristow@student.ubc.ca](mailto:sbristow@student.ubc.ca)  I will respond to emails within working hours 9am to 5pm Monday to Friday. | MacMillan 302 | |

## Course Instructor Biographical Statement

As an Assistant Professor in Plant Physiology (UBC-LFS), my research focuses on plant-water relations, xylem transport function, drought resistance, and sustainable irrigation strategies. I obtained my Diploma in 2007 at the University of Bayreuth, Germany. In 2011, I completed my PhD at University College Dublin, Ireland, elucidating the link between cell, organ and whole-plant water transport function. During my Postdoc at the University of California-Davis, USA, I provided novel insights into xylem function using X-ray computed tomography.

## Other Instructional Staff

A course TA will assist in course demonstrations, grading and for providing feedback to your questions.

## Course Structure

The course will meet in person and is focused on in-class learning. The course will meet Tuesdays and Thursdays from 8:00 to 9:30. Each lecture will include an interactive breakout session that will facilitate problem-based learning through group discussions. A multiple-choice quiz will conclude each lecture to evaluate individual learning progress. The course will be composed of lectures providing for conceptual knowledge (‘Theory and Principles’) and for insights into application (‘Tools and Techniques’). In ‘Tools and techniques’ lectures, typical measurement procedures will be presented to you, and, if feasible, the measurement devices will be setup in class for live demonstrations.

## Schedule of Topics

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| **Week** | **Lecture** | **Date** | **Topic** |
| 1 | 1 | Jan-10 | **1. Introduction to water and agriculture:**  Course overview |
| 2 | Jan-12 | History and current concepts of irrigation |
| 2 | 3 | Jan-17 | Tool and Techniques: Plant water status |
| 4 | Jan-19 | **2. Water and cells:**  Water potential, turgor and crop performance  Recommendation for further reading: Turner (2018) Turgor maintenace by osmotic adjustment: 40 years of progress. Journal of Experimental Botany 69, 3223-3233. |
| 3 | 5 | Jan-24 | **3. Soil, water and roots:**  Characteristics of soils |
| 6 | Jan-26 | Tools and Techniques: Soil water content  Recommendation for further reading: Jones (2006) Monitoring plant and soil water status: established and novel methods revisited and their relevance to studies of drought tolerance. Journal of Experimental Botany 58, 119-130. |
| 4 | 7 | Jan-31 | Root water absorption |
| 8 | Feb-2 | Tools and Techniques: Root hydraulics |
| 5 | 9 | Feb-7 | Root systems  Recommendation for further reading: Comas et al. (2013) Root traits contributing to plant productivity under drought. Frontiers in Plant Science 4, 1-16. |
| 10 | Feb-9 | Plant-based irrigation management  Required reading: Shackel (2011) A plant-based approach to deficit irrigation in trees and vines. HortScience 46, 173-177. |
| 6 | 11 | Feb-14 | Q/A session, discussion and review |
| 12 | Feb-16 | **4. Long-distance water tranport and transpiration:**  Ascent of sap through xylem  Recommendation for further reading: Tyree and Sperry (1989) Vulnerability of xylem to cavitation and embolism. Annu. Rev. Plant hys. Mol Biol 40, 19-38. |
| 7 | 13 | Feb-28 | Guest Lecture Dr. Mina Momayyezi (UC Davis) – 3D insights into leaf anatomy |
|  | March-2 | MIDTERM EXAM |
| 8 | 14 | March-7 | Evaporation from leaves  Recommendation for further reading: Monteith and Unsworth. Principles of environmental physics. 4th Edition |
| 15 | March-9 | Stomatal behaviour and stress thresholds |
| 9 | 16 | March-14 | Tools and Techniques: Transpiration and stomatal conductance |
| 17 | March-16 | **5. Water and fruits**  Biophysics of fruit development (part 1) |
| 10 | 18 | March-21 | Biophysics of fruit development (part 2)  Required reading: Knipfer et al (2015) Water transport properties of the grape pedicel during fruit development: Insights into xylem anatomy and function using microtomography. Plant Physiology 168, 1590-1602 |
| 19 | March-23 | Paper discussion |
| 11 | 20 | March-28 | **6. Agricultural water use:**  Water use efficiency  Recommendation for further reading: Hatfiled and Dold (2019) Water use efficiency: Advances and challenges in a changing climate. Frontiers in Plant Science 10, 103 |
| 21 | March-30 | Field trip UBC Totem Field |
| 12 | 22 | April-4 | Irrigation scheduling  Recommendation for further reading: Jones (2004) Irrigation scheduling: advantages and pitfalls of plant-based methods, Journal of Experimental Botany, 55, 2427–2436. |
| 23 | April-6 | Tools and Techniques: Stem water potential (field trip UBC Greenhouses) |
| 13 | 24 | April-11 | Paper discussion: Recommended and required readings |
| 25 | April-13 | Q/A session, discussion and review |
| TBD |  |  | FINAL EXAM |

## Learning Outcomes

This course will provide you with the conceptual knowledge to debate plant structure-function relationships in the context of crop irrigation requirements and productivity. At the end of this course, you will be able to:

* Debate the impact of climate change on agricultural production.
* Identify irrigation practices that promote sustainable agriculture through water savings.
* Discuss the water potential concept.
* Interpret the link between root regulation, xylem transport and stomatal behavior.
* Identify physiological stress thresholds across multiple organizational levels.
* Examine techniques to monitor soil and plant water status.
* Recognize the impact of plant anatomical and physiological traits in crop performance.

## Learning Activities

Learning activities will include in-person participation in breakout groups for group discussions, problem-based learning, and multiple choice quizzes. Recommended readings are intended for further study beyong the scope of this course. Learning activities will be largely in-person. In breakout sessions (15 minutes), you be assigned to a group (2-4 students depending on class size). You will be provided with one problem-solving question that relates to lecture content or required readings. Breakout groups are followed by group discussions (10min). Breakout groups are intended to encourage critical thinking and prepare you for solving/answering questions as they will appear in midterm and final exams.

## Learning Materials

Material will be provided in the weekly modules on Canvas. This will include links to papers. The course will follow principles as stated in the following books:

-Kramer and Boyer, Water Relations of Plants and Soil (Academic Press)

-Park Nobel, Physiochemical and Environmental Plant Physiology (Academic Press)

Internet and laptop access is recommended in-class. Upon request, access to computers can be obtained through UBC Learning Center. Access to lecture content will be provided on Canvas.

## Assessments of Learning

Assessment will be based on successfully participation and quality of your asignments

**Distribution of Marks**

* Course attendance 10%
* Multiple choice quizzes 30%
* Midterm exam 30%
* Final exam 30%

Total 100%

**Summary of Assessments of Learning**

Course attendance: In-person presence is required for successful completion of the course. You will receive a 1-point attendance score per session.

Multiple choice quiz:A four question multiple-choice quiz relating to the lecture content (and required readings) will be given to you 10 min before the end of each class. You have until 11:59pm the same day to complete the online quiz. The quiz will be accessible on Canvas. The goal of this quiz is to evaluate your learning progress.

Midterm and Final Exams:Questions for midterm and final exams will be multiple choice (in total 40) based on lecture content. Questions are similar in style as during weekly multiple choice quizzes. The final exam will focus on lecture content after the midterm. Exams will focus on conceptual knowledge, problem solving and critical thinking.

## COURSE Policies

The course will provide an inclusive environment where everybody is treated fairly and is equally respected regardless of ethnic or cultural background. **Excused absence (course attendace, exams) is limited to:**

* Illness (including mental or behavioral health).
* Family emergency, death in the immediate family.
* Observance of a religious holiday or event.
* Situations beyond the control of the student.

If so, please inform me by email including your official reason of absence for me to review and for my records.

### Learning Analytics

The course will use Canvas to obtain information on learning activities. Learning resources are available through Student Services, <https://students.ubc.ca/enrolment/academic-learning-resources>.

### Copyright

All materials of this course (course handouts, lecture slides, assessments, course readings, etc.) are the intellectual property of the Course Instructor or licensed to be used in this course by the copyright owner. Redistribution of these materials by any means without permission of the copyright holder(s) constitutes a breach of copyright and may lead to academic discipline. Students are permitted to record the class.