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Peer Review of Teaching: ET Theory, Deficit Irrigation and Consumptive Use

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Peer Review of Teaching: ET Theory, Deficit Irrigation and Consumptive Use

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Course: Advanced Irrigation Management
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BSE Peer Review of Teaching
Department of Biological Systems Engineering
University of Nebraska-Lincoln

Abstract

A BSE Peer Review of Teaching was carried out for a graduate level course on Advanced Irrigation Management. This course has been offered for several years; each time improvements are made, but there is always a need for additional improvement. In particular, ET theory, deficit irrigation, and consumptive use are topics that the students struggle to grasp. These topics involve a relatively high level of math for an MS-level (800-level) Agricultural Systems Technology course, and the available materials on these topics either were not well developed or were not a good fit for this class. The primary objective was to develop clear lecture materials, readiness test questions, homework problems, and exam questions on these particular topics. Results from Post-Pre Survey indicated a large increase in the students' self-assessed skills (related to learning objectives) during the semester. Future course improvements should include updating the course sequence of topics to provide a more uniform distribution of workload for the students.

Introduction

Advanced Irrigation Management is a graduate-only course in Agricultural Systems Technology (AGST 855). It was previously offered as Mechanized Systems Management (MSYM) 855, before the course prefixes changed from MSYM to AGST. In prior years (2015, 2017, 2019, 2020), course enrollment ranged from seven to 12 students. In 2023, when the BSE Peer Review of Teaching was carried out, the class had 11 graduate students from eight countries. Dr. Saleh Taghvaeian, as co-instructor of the course, served as the Peer Reviewer since he had frequent observation of the teaching and interaction with the students in the class. Specific objectives for improving the course were:

1) Develop clear lecture materials on ET theory, deficit irrigation, and consumptive use (build on earlier lectures and assigned reading, emphasize subtopics that most closely align with course learning objectives, and prepare students for later content in the course)
2) Develop readiness test questions, homework problems, and exam questions at an appropriate level of difficulty which will help the students internalize the lecture content on ET theory, deficit irrigation, and consumptive use

3) Provide a highly engaging learning environment for the students, both during lecture and outside of lecture
4) Preserve high-quality course materials (PowerPoint presentations, MS Whiteboard notes, video of lectures) on all topics which can be used in future online courses

The primary means of evaluation was assessment and feedback from the Peer Reviewer. In addition, a Post-Pre Survey was conducted at the conclusion of the course which provided a quantitative assessment of student learning.

Development of Course Material

New course materials were developed for ET theory, deficit irrigation, and consumptive use, including lecture materials, homework problems, readiness test questions, and exam questions. Lectures generally used PowerPoint presentations to introduce topics and whiteboard notes (using the Whiteboard app on a MS Surface) to work through the material. Demonstrating concepts on the whiteboard requires students to be actively engaged, particularly for quantitative material. The whiteboard notes on ET theory, deficit irrigation, and consumptive use are included here (Figures 1-6).

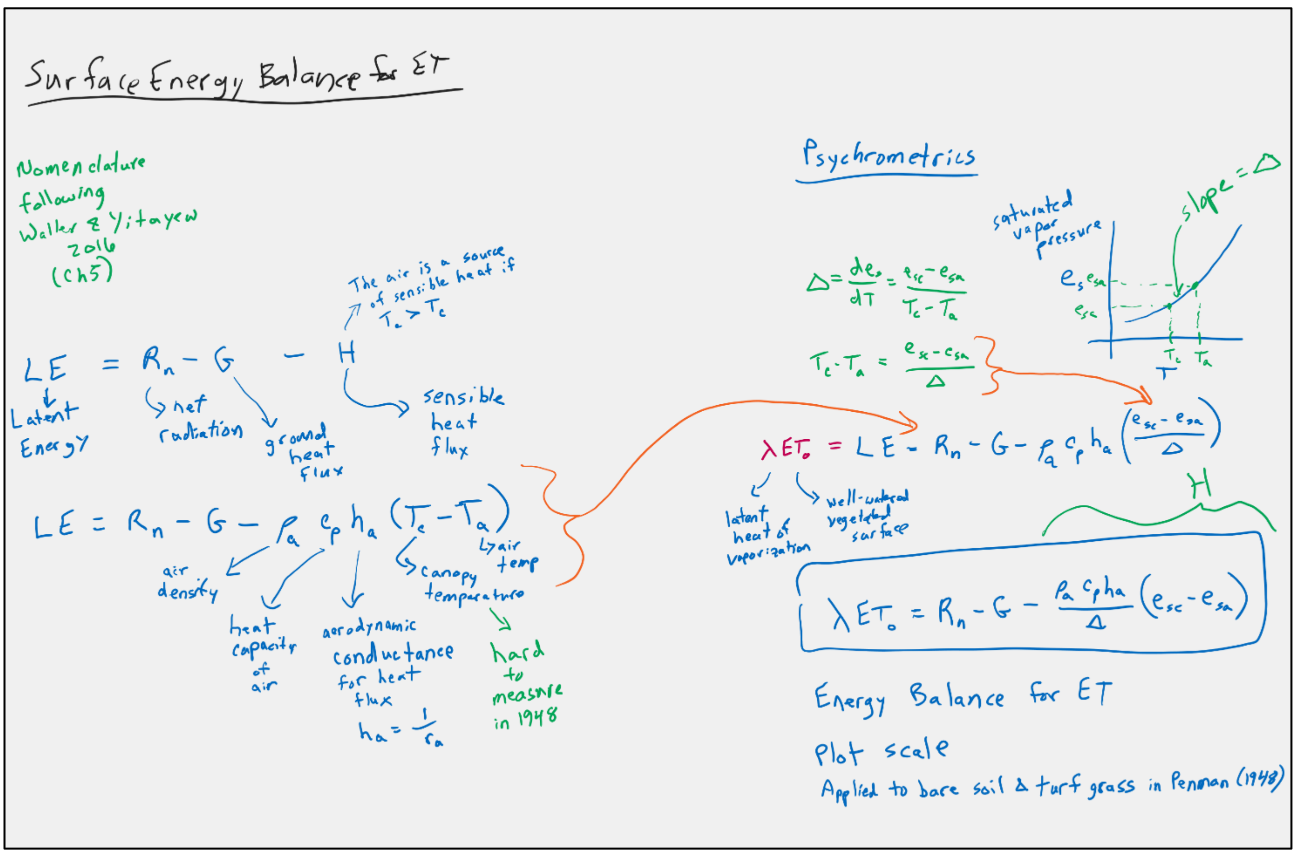


Figure 1. ET theory whiteboard notes, part 1. Builds on Waller and Yitayew (2016).

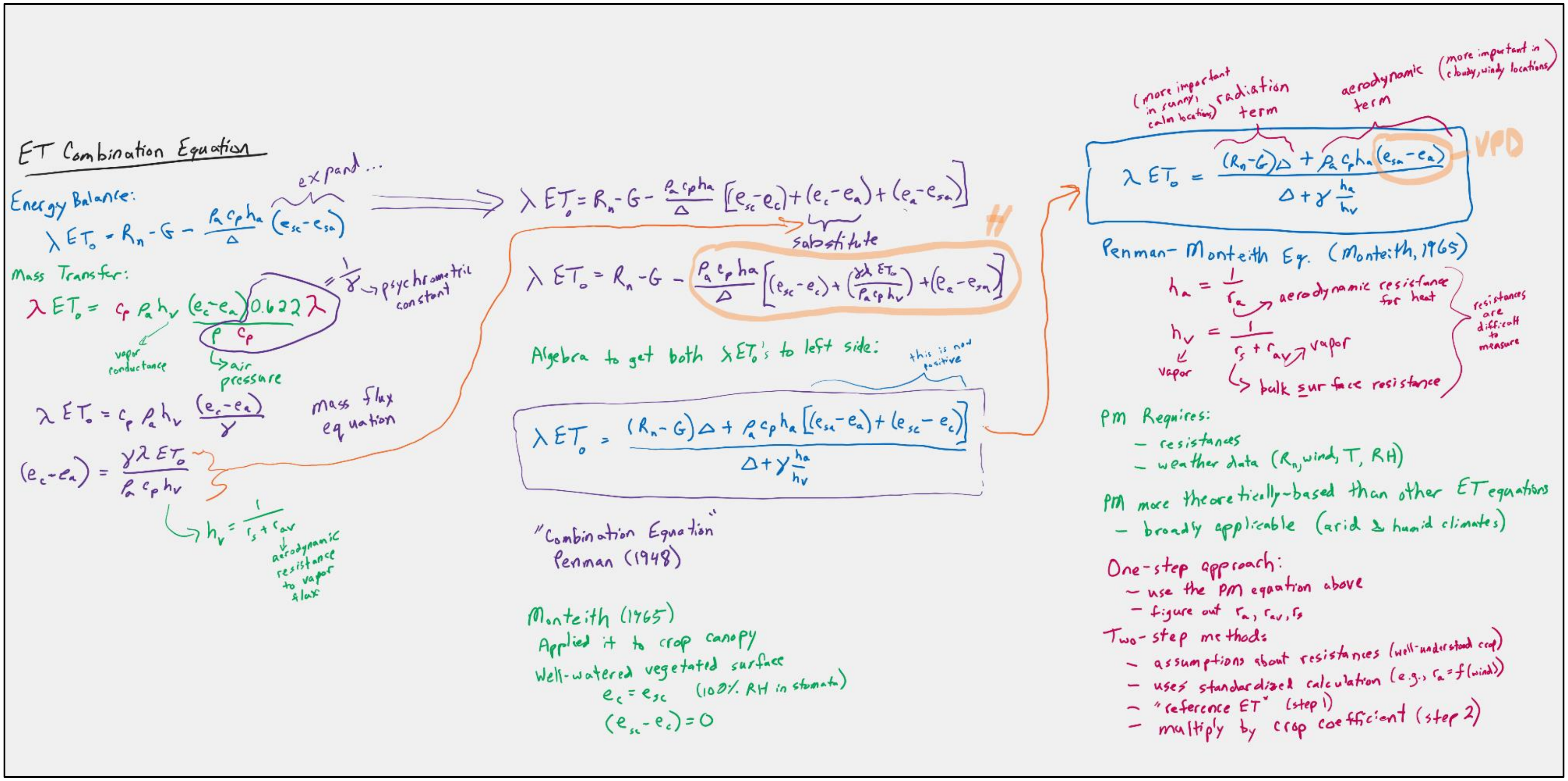


Figure 2. ET theory whiteboard notes, part 2. Builds on Waller and Yitayew (2016).

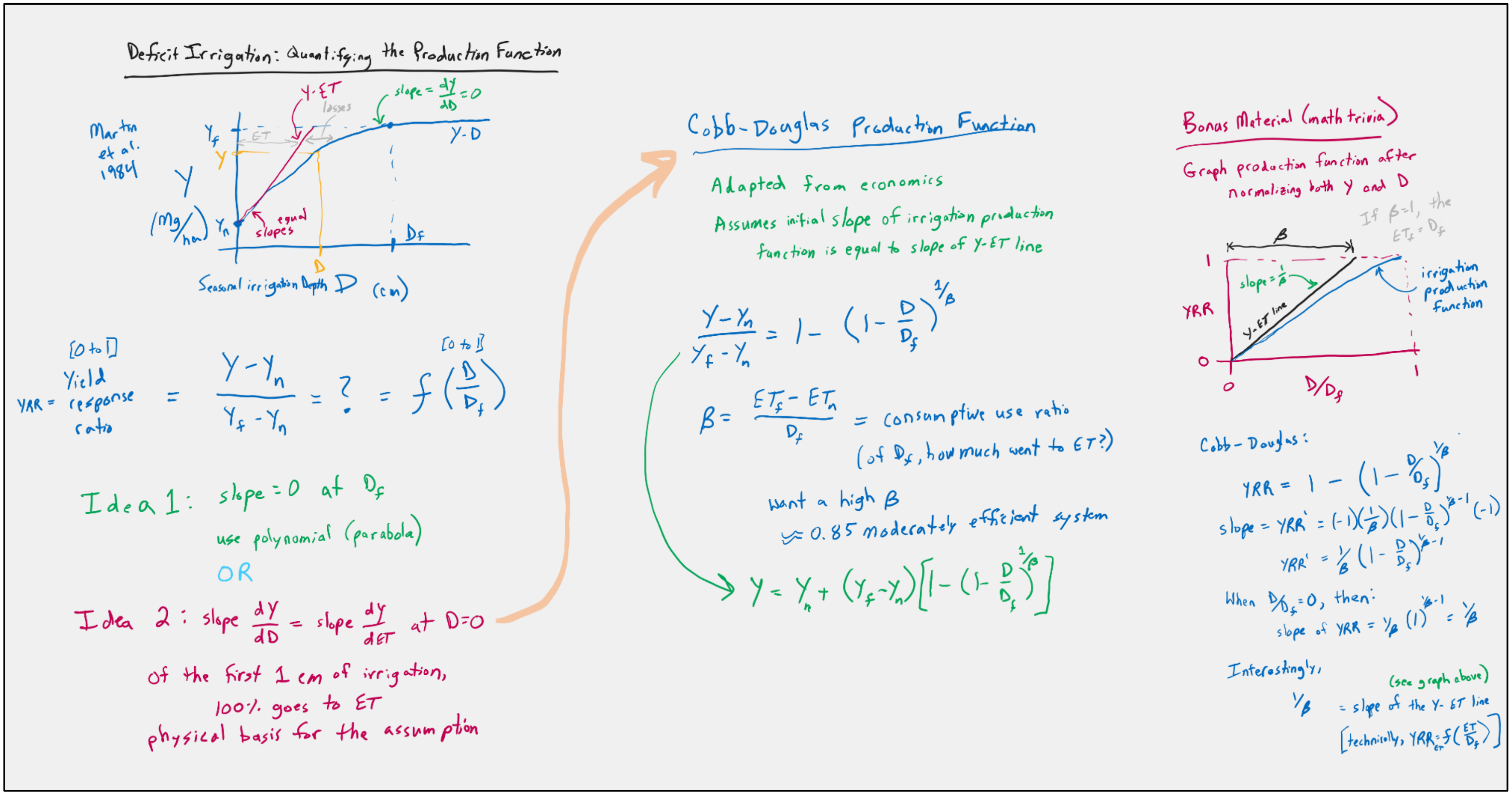


Figure 3. Deficit irrigation whiteboard notes, part 1. Builds on Martin et al. (2010).

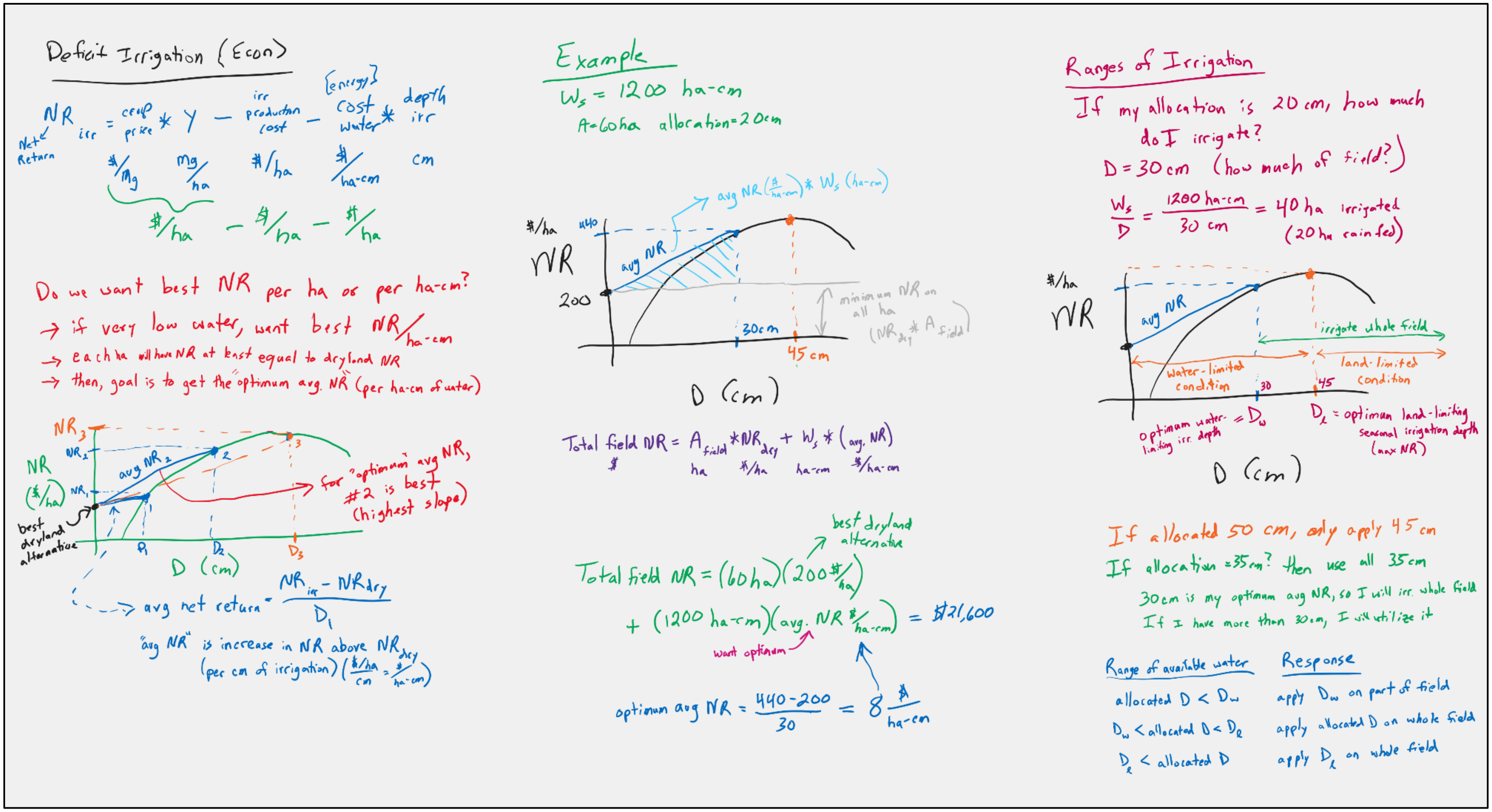


Figure 4. Deficit irrigation whiteboard notes, part 2. Builds on Martin (2013) and Banda et al. (2019).

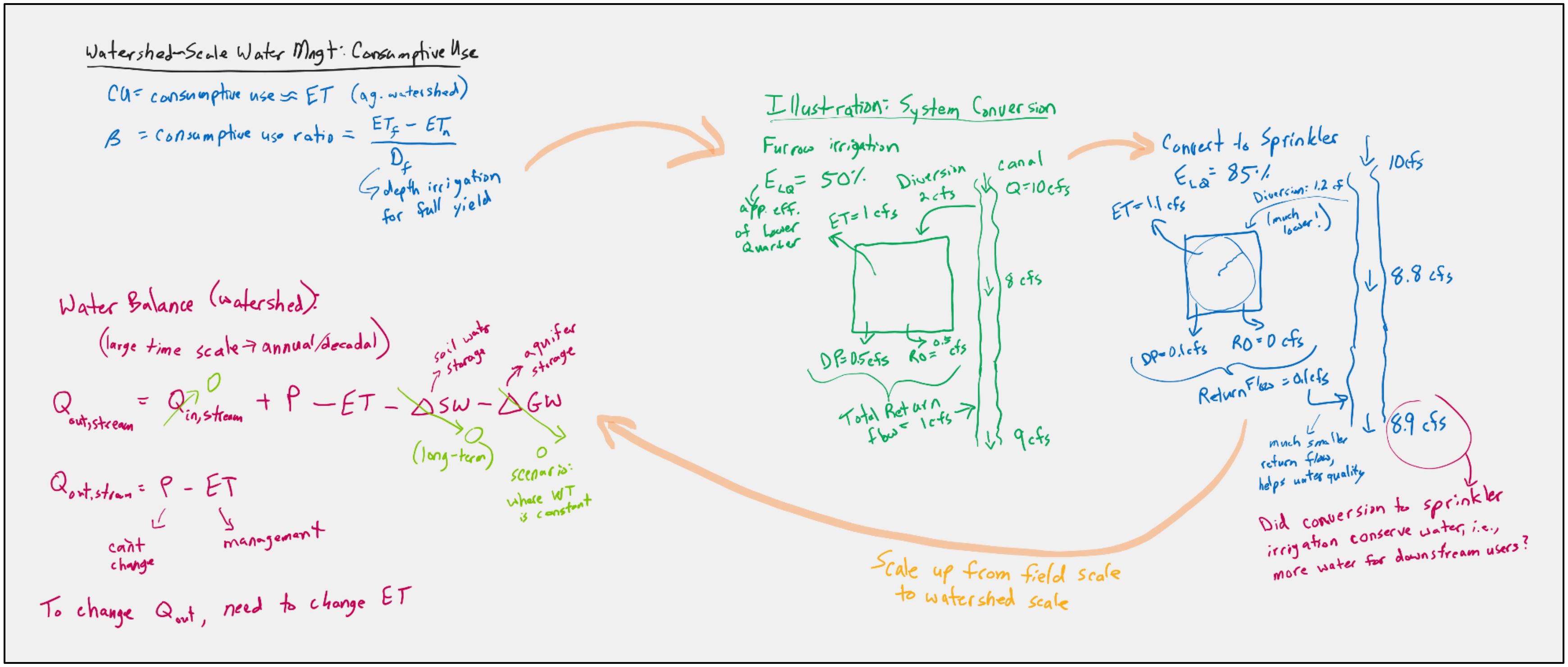


Figure 5. Consumptive use whiteboard notes, part 1. Builds on lecture material from Derrel Martin (unpublished).

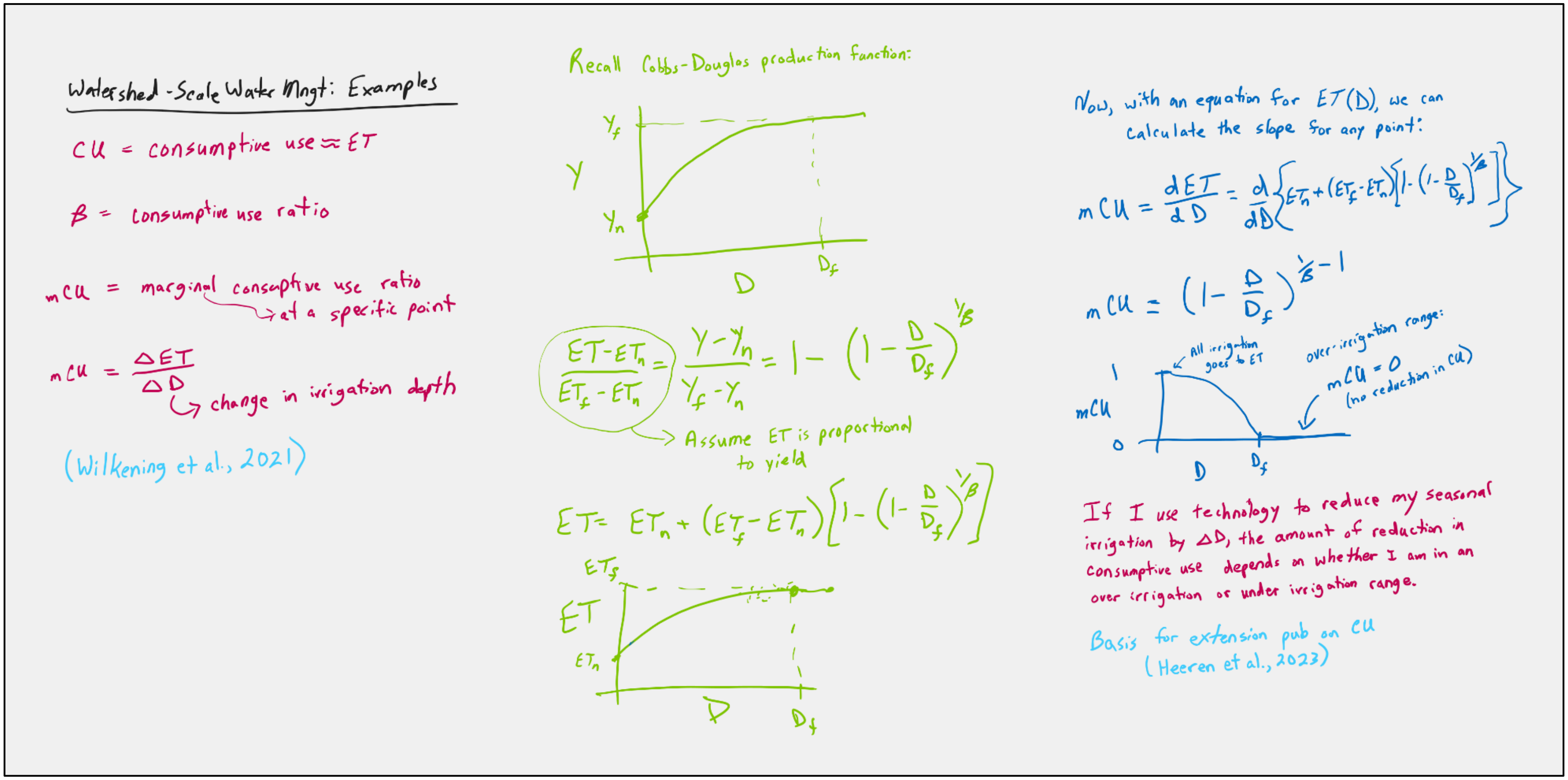


Figure 6. Consumptive use whiteboard notes, part 2. Builds on Wilkening et al. (2021) and Heeren et al. (2023).

Post-Pre Survey

A Post-Pre Survey was administered at the end of the semester on May 10, 2023 as a way to assess student learning (Table 1). Of the eleven students in the class, nine students were present at that time and completed the survey. Results indicated a large increase in the students' self-assessed skills for each learning objective. The increase for economics of deficit irrigation, as well as the surface energy balance for ET, was larger than the increase for impacts of irrigation on consumptive use.

Table 1: Results of the Post-Pre Survey (n=9). The statements in the survey correlate to the learning objectives in the syllabus. For each learning objective, the table shows the number of students who selected each response.

BEFORE starting the course				**Please select the answer that best describes how well you are able to do the following. How well are you able to…**	**AFTER completing the course**			
Very well	Somewhat	Not very well	Not at all		Very well	Somewhat	Not very well	Not at all
	3	3	3	…apply economics, including the time value of money, to compare alternative investments in irrigation systems?	6	3		
1	1	5	2	…apply soil-plant-atmosphere-water relations to calculate water flux?	5	4		
	6	3		…quantify water productivity and yield production functions?	7	2		
	1	4	4	…quantify economics (net return) of deficit irrigation and compare deficit irrigation alternatives (Water Optimizer)?	3	6		
1	2	5	1	…describe the surface energy balance and the combination equation for ET?	6	3		
	3	5	1	…calculate ET using the two-step approach (reference ET and crop coefficient)?	6	3		
1	4	2	2	…describe remote sensing for ET and irrigation management?	4	5		
	1		8	…utilize a soil water balance approach (KanSched) for irrigation scheduling?	7	2		
			9	…simulate crop growth, ET, and yield (AquaCrop) to evaluate alternative irrigation management strategies?	3	6		
1	3	3	2	…discuss operation and maintenance of sprinkler irrigation systems?	5	3	1	
1	4	4		…discuss operation and maintenance of surface irrigation systems and apply an adaptive approach (based on advance time) to surface irrigation scheduling?	6	3		
	3	3	3	…describe current apps available for irrigation system operation (monitoring and control) and irrigation scheduling?	3	6		
		5	4	…discuss components, operation, and maintenance of irrigation districts?	3	6		
	1	6	2	…describe the various roles of people involved in irrigation management and irrigation district management?	4	5		
1	3	5		…quantify impacts of irrigation management on consumptive use and water resources?	6	3		
	4	5		…discuss environmental impacts and sustainability of irrigation?	6	3		
	1	4	4	…discuss various approaches and considerations for international irrigation development?	2	7		

Peer Reviewer Assessment (completed by Saleh Taghvaeian)

1. Summarize the appropriateness and effectiveness of the teaching materials provided to you.

   The teaching material covered a wide range, from related chapters in textbooks to research articles and reports and class notes and power-point slides. The technical depth of the material provided was appropriate and consistent with the level and intended objectives of this course. The diversity of the teaching material was very helpful in explaining the concepts and serving different learning styles of students.

2. Describe the instructional strategy that you observed.

   The instructional strategy was carefully designed to engage students and keep them interested in the topics. Use of different technologies, designing reading and homework assignments before and after each lecture, having student-led discussions during the class, and inviting guest speakers to present on special topics were all different aspects of a comprehensive and inclusive strategy that was effective in achieving the learning objectives.

3. Describe the student engagement in the classroom. In what ways was the instructor responsive to students' level of engagement?

   The students were highly engaged in the classroom. The quantity and quality of their questions and comments were at a level that transformed the lectures into a two-way dialogue and even made the instructors pause and think about some of the questions. Students were eager to volunteer for leading discussions and worked collaboratively in their teams on different projects.

4. Describe the instructor-student, and peer-to-peer interaction. In what ways did the interaction help or impede learning?

   The students were provided with numerous opportunities to interact with the instructors and their peers. These interactions included asking questions and making comments at any time during lectures, participating in student-led discussions on relevant research articles, and working on homework assignments in groups of 3-4. The students also had the opportunity to interact with guest speakers, which served both educational and network development purposes.

5. Summarize the appropriateness and effectiveness of strategies used by the instructor to assess student learning.

   Student learning was evaluated using three main methods: i) in-class discussions and responses to questions asked by the instructor, ii) quizzes and exams (including readiness tests and mid-term and final exams), and iii) individual and team assignments. These frequent assessments allowed for a continuous monitoring of progress and provided students with critical information on their performance throughout the semester, which enabled them to seek help if needed and manage their time accordingly.

6. Other comments/feedback or response to instructor-specified aspects:

   Thanks for the opportunity to observe your teaching and for answering my questions about the goals behind each implemented strategy. I am planning to use some of these methods in the courses I teach. Based on my observations in the class and conversations with students, they were extremely satisfied with the quality of the education they received in this class.

Post-Review Summary

I would like to thank Dr. Taghvaeian for serving as Peer Reviewer, providing written comments above, and providing oral feedback during the Post-Review Meeting. His expertise and involvement as co-instructor resulted in valuable ideas for improvement. Some key points from our meeting are included here:

The course is currently heavy in quantitative topics and assignments at the beginning of the course; the order of topics could be adjusted to better distribute the workload for the students. To accomplish this, the irrigation scheduling and AquaCrop topics could be moved later in the semester (e.g., after two-step ET), which would work well since these two topics build on the ET material.

Some of the standalone topics at the end of the course could be moved up toward the beginning of the semester. Possible topics include irrigation districts, operation and maintenance for surface irrigation systems, and operation and maintenance for center pivot systems. Students did struggle with the homework and exam problems on the adaptive management approach for furrow irrigation—in the future we could increase emphasis on these calculations during the lecture.

In terms of the three topics that were the focus of this BSE Peer Review of Teaching, the homework problems on ET theory and deficit irrigation worked out well. The homework problem on consumptive use applied a watershed-scale water balance in southwest Nebraska. The problem was intended to help students understand the impact of field-scale irrigation management (furrow irrigation, sprinkler irrigation, no irrigation) on deep percolation and streamflow over long time periods. To do this, the problem assumed that the water table elevation remained constant in the long term (i.e., aquifer storage was constant). However, when using realistic numbers for precipitation, ET, and irrigation, baseflow (and total streamflow) for the watershed was negative. Physically this is not possible; mathematically, it is telling us that we violated our assumption about aquifer storage (in other words, irrigation in this semi-arid region almost inevitably results in aquifer decline). Next time, the problem could be adjusted to focus on aquifer depletion instead of streamflow. Alternately, the problem could be relocated to northeast Nebraska, a sub-humid region where the assumption of constant aquifer storage is more viable; this would result in a more direct correlation between field-scale management and streamflow.

References

Banda, M. M., Heeren, D. M., Martin, D. L., Munoz-Arriola, F., & Hayde, L. G. (2019). Economic analysis of deficit irrigation in sugarcane farming: Nchalo Estate, Chikwawa District, Malawi. ASABE Annual International Meeting, Paper No. 1900852, Boston, Mass. 19 pages. Available at: https://digitalcommons.unl.edu/biosysengfacpub/607/.

Heeren, D. M., Wilkening, E., Hallum, D., McCullough, C., Keshwani, J., & Schellpeper, J. (2023). Impact of irrigation technologies on water use: Clarifying water withdrawals and consumptive use. NebGuide g2345, Nebraska Extension.

Martin, D. L., Supalla, R. J., Thompson, C. L., McMullen, B. P., Hergert G. W., & Burgener, P. A. (2010). Advances in deficit irrigation management. Paper No. IRR10-9277. 10 pages. ASABE: St. Joseph, Mich. https://doi.org/10.13031/2013.35870.

Martin, D. L. (2013). Predicting yield and economics from deficit irrigation. Deficit Irrigation Workshop, Nebraska Extension.

Waller, P., & Yitayew, M. 2016. *Irrigation and Drainage Engineering*. Springer International Publishing. https://doi.org/10.1007/978-3-319-05699-9.

Wilkening, E. J., Heeren, D. M., Hallum, D., Schellpeper, J., & Martin, D. L. (2021). Impact of irrigation technologies on withdrawals and consumptive use of water. ASABE Annual International Meeting (virtual), Paper No. 2101114. 11 pages. Available at: https://digitalcommons.unl.edu/biosysengfacpub/765/.

Appendix

The following pages include the course syllabus and examples of the students' work (anonymous) for homework problems related to ET theory and deficit irrigation.

Syllabus

AGST 855 Advanced Irrigation Management
Spring 2023

Class Time: 2:00-3:15 Monday and Wednesday
Chase Hall 149

Instructors:

Dr. Derek M. Heeren
239 Chase Hall; 402-472-8577; derek.heeren@unl.edu
Website: https://bse.unl.edu/faculty/derek-heeren

Dr. Saleh Taghvaeian
231 Chase Hall; 402-472-7180; saleh.taghvaeian@unl.edu
Website: https://bse.unl.edu/faculty/saleh-taghvaeian

Textbook:

Selected chapters from: Eisenhauer, D. E., Martin, D. L., Heeren, D. M., & Hoffman, G. J. 2021. *Irrigation Systems Management*. ASABE: St. Joseph, Mich. Open access, available at: https://asabe.org/ism. Hard copy available for purchase at: https://www.amazon.com/gp/product/1940956420. doi: 10.13031/ISM.2021

Selected chapters from: NRCS. 1997. *Irrigation Guide*. National Engineering Handbook. USDA.

Chapters 2 and 5 from: Waller, P., & Yitayew, M. 2016. *Irrigation and Drainage Engineering*. Springer International Publishing.

Chapter 10 from: Martin, D. L., Kranz, W. L., Smith, T., Irmak, S., Burr, C., & Yoder, R. 2017. *Center Pivot Irrigation Handbook*. EC3017. Nebraska Extension: Lincoln, Nebr.

Selected chapters from: Mateos, L., & Sagardoy, J. A. 2014. *Guidelines on Irrigation Scheme Operation and Maintenance*. UN FAO.

Chapters 4 and 10 from: Hargreaves, G. H., & Merkley, G. P. 1998. *Irrigation Fundamentals*. Water Resources Publications, LL.

Prerequisites:
AGST 852 Irrigation Systems Management, or AGEN/BSEN 853 Irrigation and Drainage Systems Engineering, or instructor permission.

Course Description:

Theory and practice of on-farm irrigation management including: irrigation economics; soil-plant-water relations; evapotranspiration; remote sensing; irrigation scheduling; real-time operation and maintenance of irrigation systems; yield response functions and deficit irrigation; sensors and apps for irrigation; environmental impact of irrigation and drainage; impact of irrigation on consumptive use at the watershed scale; irrigation district operation and maintenance; and international irrigation development.

Objectives:

Following the course, students should be able to:

1. Apply economics, including the time value of money, to compare alternative investments in irrigation systems.
2. Apply soil-plant-atmosphere-water relations to calculate water flux.
3. Quantify water productivity and yield production functions.
4. Quantify economics (net return) of deficit irrigation and compare deficit irrigation alternatives (Water Optimizer).
5. Describe the surface energy balance and the combination equation for ET.
6. Calculate ET using the two-step approach (reference ET and crop coefficient).
7. Describe remote sensing for ET and irrigation management.
8. Utilize a soil water balance approach (KanSched) for irrigation scheduling.
9. Simulate crop growth, ET, and yield (AquaCrop) to evaluate alternative irrigation management strategies.
10. Discuss operation and maintenance of sprinkler irrigation systems.
11. Discuss operation and maintenance of surface irrigation systems and apply an adaptive approach (based on advance time) to surface irrigation scheduling.
12. Describe current apps available for irrigation system operation (monitoring and control) and irrigation scheduling.
13. Discuss components, operation, and maintenance of irrigation districts.
14. Describe the various roles of people involved in irrigation management and irrigation district management.
15. Quantify impacts of irrigation management on consumptive use and water resources.
16. Discuss environmental impacts and sustainability of irrigation.
17. Discuss various approaches and considerations for international irrigation development.

Schedule:

Date	Lecture Topic	Reading	Article Review	Comments
1-23	Introduction	Ch1.1-1.3 in *ISM*		
1-25	Irrigation Management; Irrigation Economics	Ch2 of Waller & Yitayew (2016)		RT 1
1-30	Soil-Plant-Water Relations (flux equations, resistances)	Ch4.2 in *ISM*	Ward (2014)	
2-01	Soil-Plant-Water Relations (effects of weather, retention curves); Irrigation Development	Ch2.4 & 2.10 in *ISM*, Ch4.4 & 4.5 in Hargreaves & Merkley (1998)		RT 2
2-06	Irrigation Scheduling Review	Ch6 in *ISM*	Koester et al. (2015)	Hmwk 1 due (7th)
2-08	Irrigation Scheduling Tools	Ch6 in *ISM*		RT 3

Date	Lecture Topic	Reading	Article Review	Comments
2-13	Water Productivity (production functions, yield response to stress)	Ch10 (p103-106) of Martin et al. (2017)	Taghvaeian et al. (2020)	Hmwk 2 due (14th)
2-15	Deficit Irrigation (introduction, quantifying production functions)	Ch10 (p107-111) of Martin et al. (2017)		RT 4
2-20	AquaCrop		Araya et al. (2016)	
2-22	AquaCrop			
2-27	AquaCrop		Garcia-Vila et al. (2009)	Hmwk 3 due (28th)
3-01	**Central Plains Irrigation Conference (attendance required)**			
3-06	Deficit Irrigation (economics, Water Optimizer)	Ch10 (p111-117) of Martin et al. (2017)		
3-08	**Midterm Exam**			
3-13	**Spring Break, No Class**			
3-15	**Spring Break, No Class**			
3-20	ET Theory (surface energy balance, combination equation)	Ch5 (p70-74) of Waller & Yitayew (2016)		
3-22	Two-Step ET (introduction, reference ET)	Ch4.5-4.6 of *ISM*		RT 5
3-27	Two-Step ET (crop coefficients, Kc curve)	Ch4.5-4.6 of *ISM*	Zayed et al. (2017)	
3-29	Remote Sensing of ET (basics, ET, ET models)		Kisi (2014)	Hmwk 4 due (30th)
4-03	Operation and Maintenance of Surface Irrigation Systems	Ch10.5-10.8 in *ISM*		RT 6
4-05	Operation and Maintenance of Center Pivot Systems (system components, sprinkler packages, system performance)	Ch13.5-13.7 in *ISM*	Johansen et al. (2022)	
4-10	Irrigation Districts Overview	Ch1-2 in Mateos & Sagardoy (2014)		
4-12	Irrigation Districts Operation	Ch3-5 in Mateos & Sagardoy (2014)	Dechmi et al. (2003)	
4-17	Irrigation Districts Maintenance	Ch6-7 in Mateos & Sagardoy (2014)		RT 7
4-19	Watershed-Scale Water Management (consumptive use, examples)	Heeren et al. (2023) NebGuide g2345		
4-24	Irrigation Sustainability	Ch1.4 in *ISM*	Rosa et al. (2020)	Hmwk 5 due (21st)
4-26	Environmental Impacts of Irrigation	Ch14 in NRCS Irr Guide; Ch7 in *ISM*		RT 8
5-01	International Irrigation Development	Ch4 in Hargreaves & Merkley (1998), Ch5 in NRCS Irr Guide	DWFI (2020)	
5-03	Irrigation System Operation Apps			
5-08	**Water for Food Global Conference (attendance required)**			
5-10	International Irrigation Development	Ch10 in Hargreaves & Merkley (1998)		
5-16	**Final Exam, 1:00-3:00 p.m., Chase 149**			

Example Submitted Homework Problems:

AGST 855 Advanced Irrigation Management
Spring 2023

To: **Dr. Heeren and Dr. Taghvaeian**
From: **Team Aqua-Nile**
Date: **April 03, 2023**
Subject: **Homework 4 (Deficit Irrigation and ET Theory)**

1. *Consider the following form of the Penman-Monteith equation. (10 pts)*

$$\lambda ET_0 = \frac{(R_n - G)\Delta + \rho_a c_p h_a (e_{sa} - e_a)}{\Delta + \gamma \frac{h_a}{h_v}}$$

a. *If temperature increases, resulting in a larger e_{sa}, does ET increase or decrease? Why?*

10/10

According to the Penman-Monteith equation, ET increases because an increase in temperature causes an increase in the saturation vapor pressure deficit (e_{sa}), which increases potential evapotranspiration (ET). Higher temperatures increase the rate at which water evaporates from the soil and plants evaporate. As a result, if the temperature increases and the (e_{sa}) rises, so could ET. Furthermore, higher (e_{sa}) indicates that the air can store more moisture, providing a larger pushing force for water vapor to transfer from soil and plant surfaces into the atmosphere (ET).

b. *Wind speed appears to be missing from this form of the Penman-Monteith equation. How is wind accounted for?*

h_a and h_v can be expanded to: $h_a = \frac{1}{r_a}$ and $h_v = \frac{1}{r_a + r_v}$ where $r_a = aerodynamic\ resistance$ and $r_s = bulk\ surface\ resistance$

Wind speed is a major factor effecting aerodynamic resistance and is thus taken into account in the Penman-Monteith equation. Extending further, r_a is inversely related to wind speed (u_2) as follows: $r_a = 208/u_2$ (From Waller & Yitayew, 2016). Where u_2 is the wind speed at 2 m elevation in unit of m/s.

2. *Make a graph (in Excel) of an Irrigation Production Function for cassava in southern India. Use the Cobb-Douglas equation. The field uses a surface drip irrigation system. The non-irrigated marketable yield was 27 Mg/ha, which had a seasonal ET of 30 cm. The full yield (48 Mg/ha) required 22 cm of irrigation, resulting in 50 cm of total ET. Both the horizontal axis and the vertical axes should have labels, including units. For the scale on each axis, numbers should be limited to one significant figure (or two at the most). Include major gridlines (horizontal and vertical) so a reader can read a data point from your graph. (15 pts)*

Answer:

The Cobb-Douglas production function is:

$$\frac{Y - Y_n}{Y_f - Y_n} = 1 - \left(1 - \frac{D}{D_f}\right)^{\frac{1}{\beta}}$$

Where,

- $Y_n = 27\ \text{Mg/ha}$
- $Y_f = 48\ \text{Mg/ha}$
- $D_f = 22\ \text{cm}$
- $ET_n = 30\ \text{cm}$
- $ET_f = 50\ \text{cm}$
- $\beta = \frac{ET_f - ET_n}{D_f} = \frac{50 - 30}{22} \Rightarrow \beta = 0.91$

Substituting known values into the equation, we have

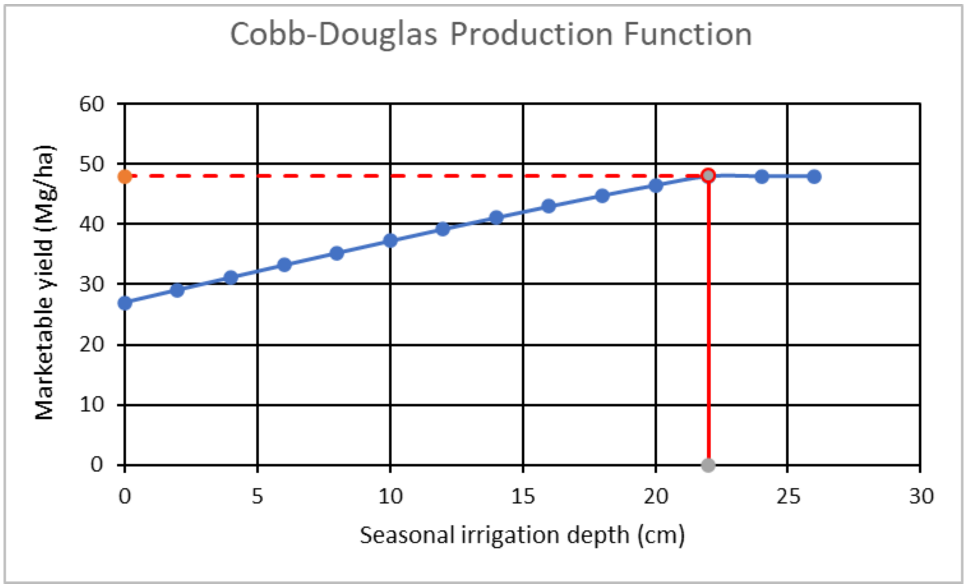
$$\frac{Y - 27}{48 - 27} = 1 - \left(1 - \frac{D}{22}\right)^{\frac{1}{0.91}}$$

15/15

Rearranging the equation to solve for Y, we have:

$$Y = 27 + (48 - 27) * \left(1 - (1 - D/22)^{(1/0.91)}\right)$$

Plotting this equation in excel yields the following graph:



The horizontal (broken) and vertical lines in red ink show the full yield (48 Mg/ha) and required irrigation depth (22 cm) at full yield, respectively.

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4. *Considering the figure below for a 130-ac center pivot irrigated maize field, determine the following: (25 pts)*

Given: A = 130 ac maize field, best dry land = 200 $/ac

25/25

Find:

a. *What is the optimum irrigation depth if water is not limited (i.e., land limited condition)?*

According to the figure below the optimum irrigation depth land limited condition (DL) = 15 in

b. *The best dryland scenario (sorghum) is marked on the graph. What would the net return for the whole field be if you didn't irrigate?*

NR not irrigate for whole field = NRdry not irr* A field ac

= 200 $/ac * 130 ac = **$26000**

c. *Draw in the line for the optimum Economic Productivity of the water,* EP_w *(also known as "average net return").* **The red one**

d. *Calculate the value of the* EP_w*.*

Given: From the fig D = 10 in, NR optimum dry = 200 $/ac, NR irr = 300 $/ac,

Find: Epw (optimum avg NR)

Eq: avg NR = (NR irr – NR dry)/ D

Slove: Epw = (300 **$/ac** - 200 **$/ac**) **/ 10** in **= 10 $/ac-in**

e. *What is the optimum irrigation depth if you had an allocation of 7 inches?*

The optimum irrigation depth = **10 in**

Since an allocation is (7 in) less than Dw (optimum water 10 in**) means is better to irrigated part of flied 91 ac used 10 in rather than 7 in for 130 ac.**

Epw for 7 in = avg NR = (NR irr – NR dry)/ D

Epw 7 in = (240 **$/ac** - 200 **$/ac**) **/ 7** in **= 5.71 $/ac-in**

Epw 10 in = (300 **$/ac** - 200 **$/ac**) **/ 10** in **= 10 $/ac-in**

Thus, it will be better to use an optimum irrigation depth of 10 in for 91 ac rath than 7 in for 130 ac, because the NR of 10 in would be higher.

f. *What is your water supply (volume)?*

Ws = D in * A ac = 7 in*130 ac = **910 ac-in**

g. *How many acres would you irrigate (using the optimum irrigation depth (Dw))?*

Given: D optimum = 10 in, A = 130 ac,

Find: irrigate area

Eq: Area irr = Ws /D (in Waller & Yitayew, 2016)

Slove:

Ws = 7 in*130 ac = 910 ac-in, D= 10 in

A irrigated = Ws / D = 910 ac-in / 10 in = **91 ac irrigated**

A not irrigated = **39 ac**

h. *What is the net return for the whole field including irrigation?*

Given: A = 130 ac , avg NR = 10 $/ac-in , Ws = 910 ac-in, NR dry = 200 $/ac,

Find: the total filed NR

Eq. the total filed NR = (A ac * NR dry $/ac) + (Ws ac-in *avg.NR $/ac-in)
NR = NR irr + NR dry

Slove:

The total NR = (A ac * NR dry $/ac) + (Ws ac-in *avg.NR $/ac-in)
T NR = (130 * 200 $/ac) + (910 ac-in * 10 $/ ac-in) =
$26000 + $9100 = **$35100**