Water Into Wine: Studying Vineyard Water Dynamics in Israel and North Carolina

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Wine-Grape Vineyards

- Domesticated grape production began ~8,000 ybp
- Culturally significant
- Produced worldwide
  (6 of 7 continents)
North Carolina Wine-Grape Vineyards

- Relatively long history – introduced in 17\textsuperscript{th} century
- Recent boom (since early 1990s)
- Currently: $1.2 \text{ B/yr impact, } >100 \text{ wineries, } >400 \text{ vineyards}
Canopy Architecture and Management

- Widely-spaced rows
- Trained canopies
- Sensitive to too much and/or too little water
- Both irrigated (typically drip) and rain-fed systems common
Wide-Ranging Growing Conditions

Negev, Israel

- Rainfall = 93 mm/yr
- Concerns: water stress
- Management aims to increase water use efficiency

North Carolina

- Rainfall = 1120 mm/yr
- Concerns: excess vegetative growth, fungal disease pressure
- Management aims to lower water availability
Complex Water Use

transpiration from vines

evapotranspiration from inter-row and beneath vines

irrigated

rain-fed

drip emitter

inter-row grass
U.S.-Israel BARD
Separating Components of Evapotranspiration to Improve Vineyard Water Management

PI: Heitman, NC State Univ.; Co-PI: Ben-Gal Israel ARO

- Develop techniques to identify components of ET in temperate and semi-arid vineyard systems
- Evaluate and refine strategies for excess water removal in temperate, rain-fed vineyards (North Carolina, U.S.A)
- Evaluate and refine strategies for water conservation for semi-arid, irrigated vineyards (Negev, Israel)
Project Site: North Carolina

- Yadkin Valley Appellation
- Surry Community College Monitoring Station
- RayLen Vineyard Monitoring Station
- Boone ASU Station
- NC A&T SU Research Farm
- UNCG Lindale Farm Station
- Piedmont Research Station
- Upper Mountain Research Station
- Upper Piedmont Research Station
Project Site: Northern Negev, Israel
Site Comparison

• Both: *V. vinifera* grapes; ~ 3 m row width, oriented N-S
• Negev: Drip irrigated, bare inter-rows, *too little moisture leads to high cost for irrigation*
• North Carolina: Rain-fed, fescue inter-rows, *too much moisture leads to disease pressure and poor quality grapes*

Northern Negev, Israel

North Carolina
Measurement Overview

- **Inter-row evapotranspiration** measured with micro Bowen ratio systems (two positions)
Measurement Overview

- **Whole system evapotranspiration** measured by eddy covariance
Measurement Overview
Outline for Remainder of Talk

I. Positional Below-Canopy Potential Evapotranspiration
II. Water Management Challenges for North Carolina
III. General Conclusions from the Negev and North Carolina
I. Positional Below-Canopy Potential Evapotranspiration
Positional Below-Canopy Potential Evapotranspiration (PET) Sub-experiment

PET measured with micro pan lysimeters; below canopy radiation measured with pyranometers

Negev, Israel

North Carolina, USA

- micro pan lysimeter
- vine row

<table>
<thead>
<tr>
<th>0</th>
<th>0.3 m</th>
<th>1.5 m</th>
<th>3.0 m</th>
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N
Global radiation vs. Time

Radiation (W/m²)

0 200 400 600 800 1000

Negev
North Carolina

Time
600 800 1000 1200 1400 1600 1800 2000

Global radiation

Radiation (W/m²)

0 1000

Time
600 800 1000 1200 1400 1600 1800 2000

Negev
North Carolina
PET Sub-experiment: Conclusions

- Diurnal shading produces spatially variable below-canopy PET; *PET is well correlated to radiation.*

- PET directly under the vines is significant – *potential evaporative water loss under the vines >72% of that observed at mid row.*

- Peak evaporation under the vine did not occur at midday – *avoiding midday drip irrigation does not necessarily provide an advantage for water conservation.*
HYDRUS 2D Model – incorporated spatially variable conditions to assess water loss via evaporation (Kool et al., 2014)
Model analysis including 205 site-seasons from western NC.

- Moderate water stress is desirable to produce high quality grapes; >70% of days have mild to no stress conditions.
- **Too much** water is a primary challenge!
Water Management Challenges for NC
Field Experiment

- **Does having grassed inter-rows help with too much water?**

- Assessed effects of inter-row management: **fescue** vs. bare soil on water use.
Fescue had 60% greater summertime ET than bare soil – *but water used in either case was far below precipitation.*
Greater fescue interrow ET had a modest effect on water availability.
But...fescue inter-row ET increased humidity by 2-5%, possibly resulting in increased potential for fungal disease.
• Current drip-irrigation management strategies are generally effective – soil water evaporation was typically <10% of total ET within the vineyard.

• Timing of irrigation according to canopy shading patterns may help to further reduce evaporation.
Inter-row cover crops use a large fraction of water, but current management practices do not produce desired water stress in most years.
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Additional Reading


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