Assessing Impacts of Direct Root-zone Irrigation on Grapevine Physiology

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Introduction

Subsurface micro-irrigation, which delivers water directly into lower root-zone of grapevines, is considered a relatively new strategy to improve water use efficiency. However, buried driplines are subject to soil clogging and chewing damage by burrowing rodents. This presentation will illustrate an improved technique to avoid these issues and deliver drip irrigation at greater depths (applied up to 1 meter below ground) than buried lines. Field work conducted in 2015 demonstrated that by using direct root-irrigation, vines receiving 60% of water applied as surface drip with full commercial rates yielded 90% of commercial grape production. To better understand the ability of subsurface micro-irrigation to sustain grapevines at reduced water amounts from surface drip delivery, both greenhouse and field site experiments were initiated to investigate the impacts on two physiological aspects: carbohydrate partitioning and root dynamics. The mini-rhizotron method is employed to observe root architecture, turnover, and calculate biomass while photosynthetic rate will be determined by auto-porometer. Results will not only help vineyard producers reduce irrigation water use while maintaining fruit production, but also lead to a better understanding of sustaining vine health during periods of drought and water shortages.

Hypotheses

Water delivered directly into the middle and lower root-zone through vertical tubes will not only save amounts of water otherwise lost to evaporation or weeds, but also help improve efficiency of carbonhydrate allocation to roots, stems, leaves, and fruits.

Objectives

1) Investigate how roots develop under different water stress levels;
2) Explore the dynamics of carbon partition in grapevines under different water stress levels and post-pruning;
3) Quantify influences of irrigation rate and depth on grape production.

Materials and Methods

Focal species: Cabernet Sauvignon (Red wine grape).

Greenhouse experiments: Vines were planted both in pots and PVC cylinders in April, 2016 (*Figure 1*). A randomized complete block design (RCBD) was used to investigate the effects of different water stress levels (high, medium, low, and no stress) and post-pruning (prune vines after growing season) on biomass partition and root growth.

Field experiment: A RCBD experiment was initiated in a commercial block located on Kiona Vineyards in early 2015 (*Figure 2*). Subsurface micro-irrigation delivered water at 0, 0.3, 0.6 and 0.9 meter depths on a schedule determined by the growers to a control treatment of standard surface drip irrigation. Rates of water applied to the subsurface treatments were about 60, 30, and 15% of the surface drip application rate and were regulated by battery powered controllers (*Figure 3*).

Root observation: Mini-rhizotron method was used both in greenhouse and field research sites to compare differences of root distribution and turnover.

Biomass evaluation: Biomass partition was calculated by harvest method; root biomass was determined both by harvest and root image analysis.

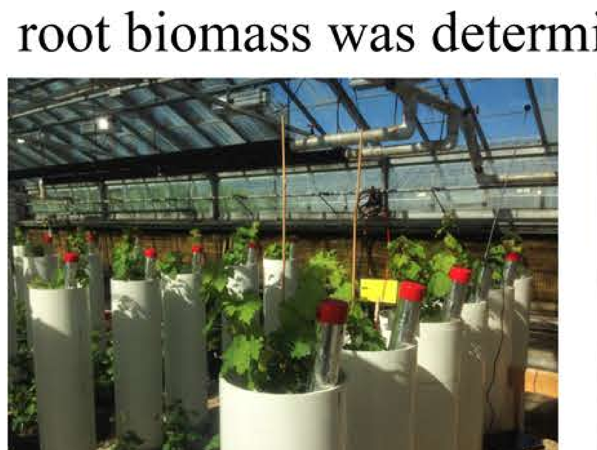

Figure 1. Greenhouse on WSU Pullman campus

Figure 2. Field site in Red Mountain AVA, WA

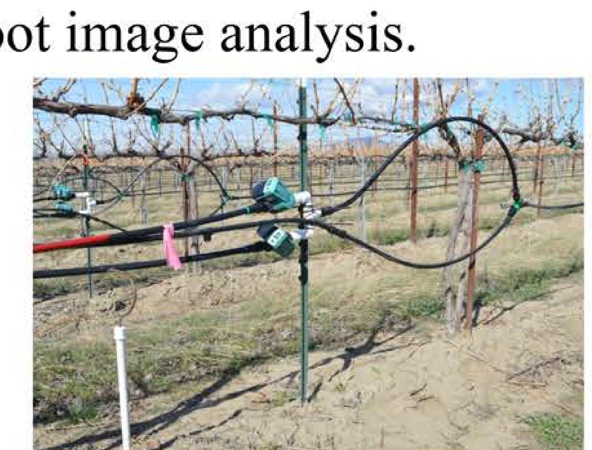

Figure 3. Battery powered controller in field site

Preliminary Results

- *Grape production: less water use with acceptable fruit production*

Vines and fruit production were maintained during extreme heat and drought conditions with only 15% the water applied as surface drip with full commercial rates (100%). With the lowest rate (15% of commercial surface drip), grape production was 70% that of the full commercial rate, and with 60% of commercial surface drip application, fruit production was only 10% less than that of commercial rates (*Figure 4*). Water use amounts were showed in Table 1.

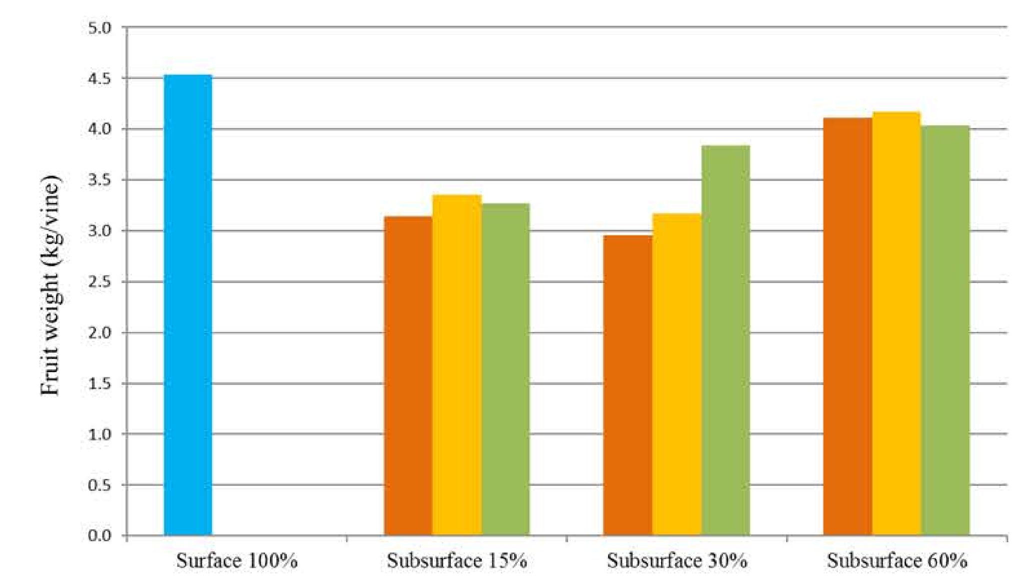

Figure 4. Fruit weight (kg/vine) at harvest in 2015. 15%, 30%, and 60% mean the irrigation rates applied in subsurface irrigation compared to the full commercial rate (100%) in surface irrigation. Illustrated data have not yet been statistically analyzed. Blue, orange, yellow, and green colors represent irrigation depths were 0, 0.3, 0.6, and 0.9 meters from the soil surface.

Table 1. Water use amounts of different irrigation rates in field study

Irrigation rate (%)	Water use amount (Liter vine^{-1} time^{-1})
100	61.32
60	36.72
30	21.20
15	10.22

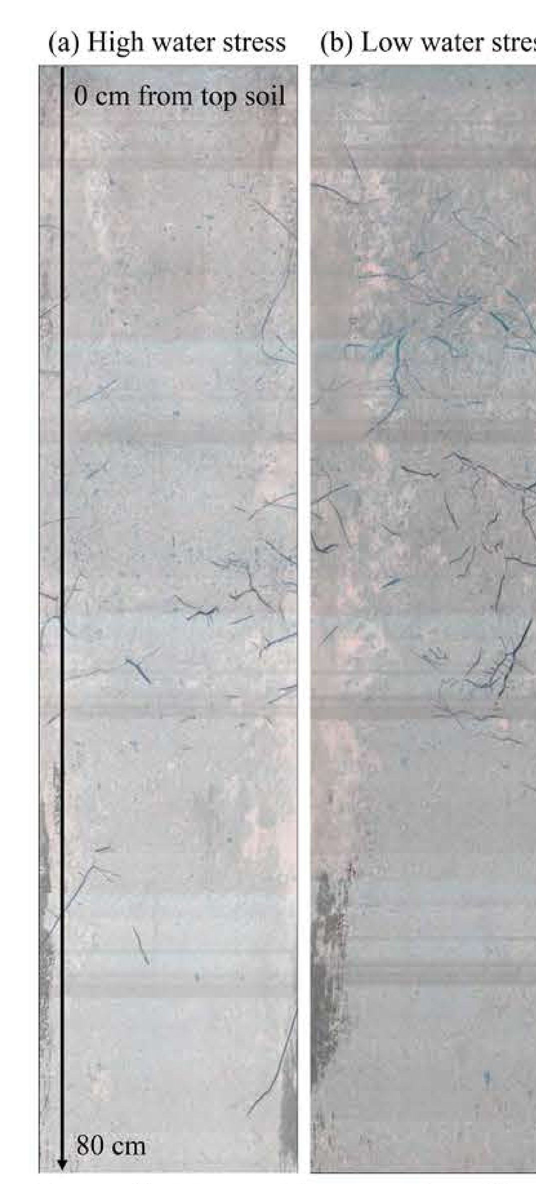

Figure 5. Root architectures (0 to 80 cm deep from top soil) under (a) high and (b) low water stresses. Roots were from separate vines in the same greenhouse experimental block. Photos were taken by CI-600 In-Situ Root Imager on July 11, 2016.

- *Root dynamics: Vines under water stress have less and deep roots (Figure 5)*
- *Biomass partition: Threshold of water stress tolerance may exist*

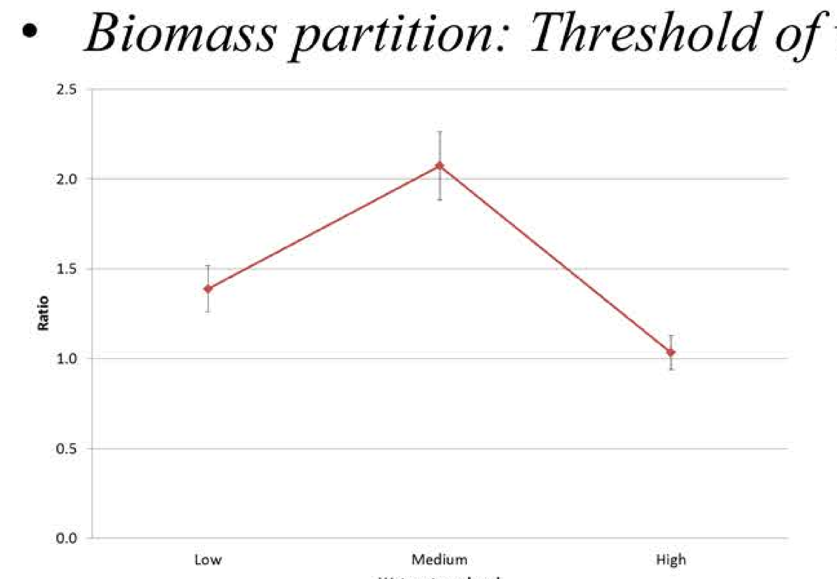

Figure 6. The ratio of belowground biomass to aboveground biomass under different water stress levels (based on water use amount per vine). Low, 1000 ml/week; medium, 700 ml/week; high, 400 ml/week. Vines were harvested by hands, dried at 65°C, and weighted separately.

Moderate water stress to some extent increased ratio of biomass allocation between below- to aboveground parts. However, extreme water stress led to ratio decrease, which might represent unhealthy condition of vines (*Figure 6*). Further analyses regarding biomass allocation in different plant organs and the pruning effect are needed.

Next Steps

1) Continue to observe root dynamics under different irrigation rates and depths, as well as pruning both in greenhouse and field studies;
2) Investigate in photosynthetic capacity of grapevines under different irrigation treatments, and to try to understand the relationships between changes of photosynthesis and carbon partitioning;
3) Conduct extension workshops and develop educational materials for vineyard managers and growers to conserve irrigation water and improve wine grape quality.

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