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# HETEROGENEITY OF DEW-PERIOD DURATION WITHIN APPLE TREE CANOPIES AND COMPARISON TO SITE-SPECIFIC WETNESS ESTIMATES

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## INTRODUCTION

The growth and spread of fungal pathogens are influenced by the duration of wetness periods. For this reason, leaf wetness duration (LWD) is a key input to many disease-warning systems (decision aids that help growers to time disease management practices, such as fungicide sprays, efficiently). On-site monitoring of LWD is unacceptable to many apple growers because it is inconvenient, laborious, and often unreliable. An alternative source of LWD data is commercially available, site-specific LWD estimation (e.g., SkyBit, Inc.). These remote estimates do not consider effects of crop canopy microenvironment, however, which may result in erroneous within-canopy LWD estimates. There is therefore a need to calibrate site-specific estimates of LWD to microenvironments in an apple-tree canopy with acceptable accuracy.

## METHODS

Hourly averages of LWD were obtained at 12 canopy positions in each of four mature, semi-dwarf apple trees (3.7 to 4.2 m tall, north-south row orientation, cv. Golden Delicious) in an Iowa State University orchard near Gilbert, IA, from late May to mid-September 2001. Painted electronic wetness sensors (Model 237, Campbell Scientific, Inc.) were mounted at a 45-degree angle from horizontal and facing north at four east-west positions within the canopy at each of three heights (3.7 m, 2.4 m, 1.2 m.). Four identical sensors were also erected 0.7 m above mowed turfgrass, facing north, on an unobstructed site 100 m north of the apple orchard. LWD for 24-hr periods from 11 am to 10 am was analyzed using a SAS Mixed Models procedure. Nights (11 am-10 am) with no measured precipitation (<0.01 in) were evaluated separately from nights with measured precipitation. Precipitation values used to determine rainy nights for on-site and SkyBit data were obtained from a tipping-bucket rain gauge located 100 m north of the apple orchard. On-site data from the apple canopies and turfgrass were used to evaluate accuracy of SkyBit estimates of LWD for microenvironments within the apple canopy.

## RESULTS

*Variation of wetness duration within apple tree canopies*

Wetness duration was least in the lower, western portion of the canopy and greatest in the upper, eastern portion of the canopy (Fig. 1). For example, wetness duration in the upper, eastern canopy was 55% greater than for the lower, western canopy on all nights. Spatial variation of wetness duration was greater during dew periods than rain periods.

*Estimation of wetness duration in apple tree canopies from data measured over turfgrass and from SkyBit remote estimates*

On-site wetness duration data measured 70 cm above turfgrass predicted wetness duration within nearby apple tree canopies most accurately on nights when measured rainfall occurred (Fig. 2). On nights without measured rainfall, turfgrass wetness measurements correlated most closely with within-canopy measurements near the top of the tree (Fig. 2).

SkyBit estimates, on the other hand, did not correlate as strongly with in-canopy wetness duration measurements from the apple trees. During nights without measured rainfall, in particular, SkyBit did not correlate well with wetness duration measurements at any point in the apple canopy (Fig. 3), and underestimated wetness duration by 2.4 to 6.16 hr per night (Fig. 1). During nights with measured rainfall, in contrast, Skybit wetness duration correlated much more closely with in-canopy wetness measurements (Fig. 3), but not as closely as the turfgrass wetness duration measurements (Fig. 2). Measurements over turfgrass and SkyBit estimates were reasonably accurate estimators of in-canopy wetness duration during rainy nights, but the turfgrass estimates were far more accurate than the SkyBit estimates during nights without measured rainfall (Fig. 1).

## DISCUSSION

Our data document clearly the substantial spatial heterogeneity in wetness duration that existed within an apple tree canopy in the North Central region of the U.S., and that this heterogeneity was far more pronounced when the wetness was caused by dew than by rainfall. Dew duration was longer in the upper than the lower canopy, presumably because overhanging leaves created a barrier that reduced cooling of leaf surfaces in the lower canopy, and therefore dew formation, on clear nights. Compared to dew, rainfall $\geq$0.01 inch tended to create much more uniform wetness duration throughout the canopy. Shorter wetness duration in the western than the eastern portions of the lower part of the apple canopy in our trial reflected a prevailing wind direction from the west, which probably caused more rapid drying on the western side of the canopy. It is unclear from our study whether these canopy wetness duration patterns can be generalized to apple orchards elsewhere. While is it reasonable to assume that these patterns could be roughly representative of mature, semi-dwarf orchards in our region of the U.S., numerous factors (e.g., tree size and cultivar, extent of pruning, row orientation, and prevailing wind direction and exposure) are likely to influence wetness duration patterns significantly even within the North Central U.S.

The superior accuracy of wetness-duration measurements from nearby turfgrass compared to remote, site-specific (e.g., SkyBit Inc.) estimates for gauging wetness duration within an apple canopy is not surprising. Site-specific weather estimates are based on factors such as site location, altitude, distance from regional weather stations, and mesoscale weather models, without regard to the architecture or even the existence of crop canopies. Our findings emphasize the need to develop models to improve wetness estimation accuracy within large crop canopies such as apples, in order to better estimate the risk of wetness-driven diseases for reliable application in disease-warning systems.

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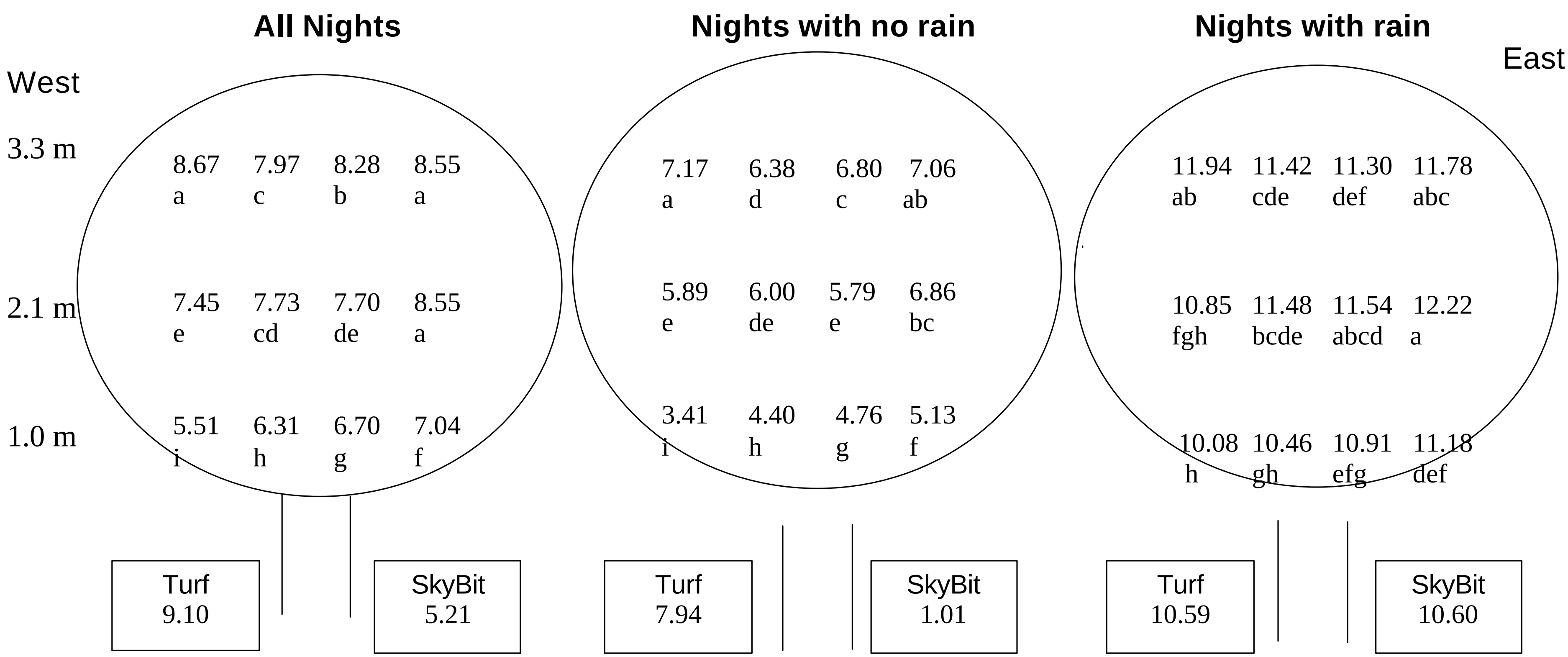


Figure 1. Mean nightly (11 am-10 am) leaf wetness duration (LWD) (hr) for 12 locations within the canopies of four Golden Delicious apple trees, for sensors placed 70 cm above mowed turfgrass located 100 m north of the apple orchard ("Turf"), and estimates from SkyBit Inc. ("SkyBit") from mid-May to mid-September 2001. All nights (n=135), nights with no measurable precipitation (n=91), and nights with precipitation ≥0.01 inches (n=44) were each analyzed using a SAS Mixed Models procedure. Wettest to driest areas within trees are denoted as a-i; means designated by different letters differed from each other at P=0.00075.

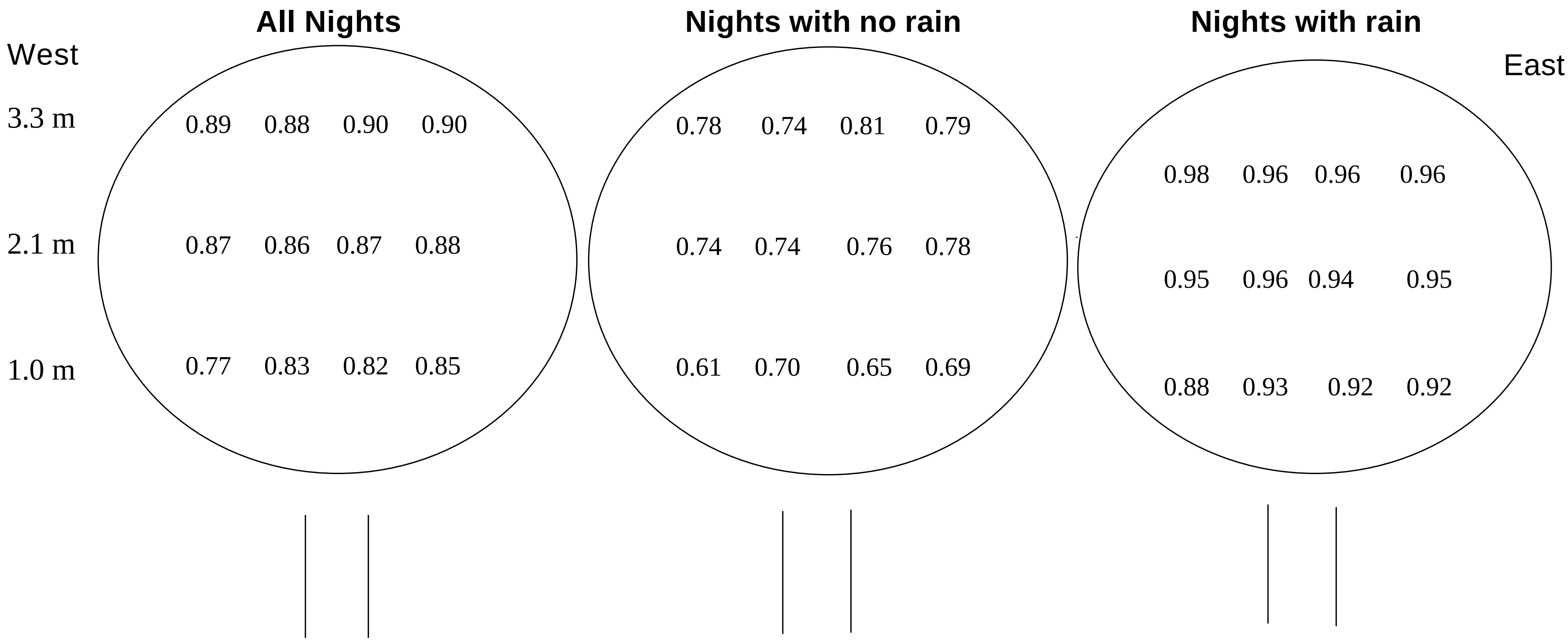


Figure 2. Pearson correlation coefficients from comparisons of nightly (11 am-10 am) leaf wetness duration (LWD) measurements at 12 locations within apple tree canopies to LWD measurements 70 cm above mowed turfgrass from mid-May to mid-September 2001. All nights (n=130), nights with no measurable precipitation (n=91), and nights with precipitation ≥0.01 inch (n=29) are designated from left to right.

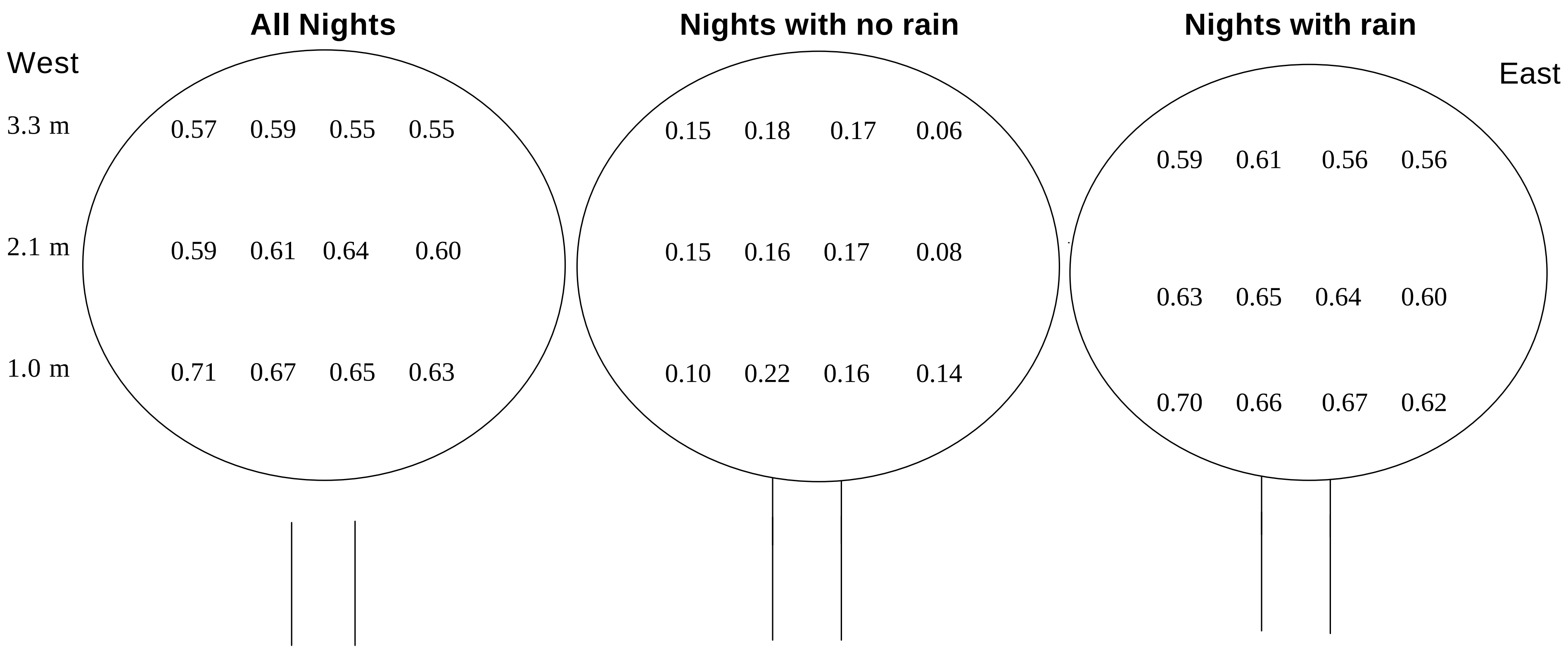


Figure 3. Pearson correlation coefficients from comparisons of nightly (11 am to 10 am) leaf wetness duration (LWD) measurements at 12 locations within apple tree canopies to LWD estimates by SkyBit Inc. from mid-May to mid-September 2001. All nights (n=130), nights with no measured precipitation (n=91), and nights with precipitation ≥0.01 in (n=29) are designated from left to right.