California Avocado Society 2002 Yearbook 86: 99-104

Slope and Aspect Effect on Evaporation as Measured by Atmometer

B. A. Faber
University of California Cooperative Extension, Ventura, CA

Abstract

Atmometers were installed on four quadrants of a hill and at three positions on the slope toe, midslope and top of hill. There was clear fetch of over 1 kilometer in all directions. The hill was within 2 kilometers from the ocean which was the prevailing wind direction for much of the day. Measurements were made over an eight month period from early summer to late winter in New Zealand. Wind played a dominant role in evaporative loss. Depending on the season, evaporative loss was affected more or less significantly by slope aspect. On all quadrants, greatest evaporative loss occurred at the top of slope and least occurred on the lee side of the hill which was most shaded.

Introduction

Avocado *(Persea americana)* in California grows primarily along the coast from San Diego to San Luis Obispo in the north. For the most part, the groves are planted on steep terrain. This is partly to improve air drainage to avoid frost damage, but also because of the lack of available flat land in these areas. Slopes in some groves can exceed 75 degrees (Staff, 1982). The uneven nature of the terrain also means that many groves are planted to more than one aspect. Some of the groves are quite small (<1 hectare) while others can be in the 50-100 hectare size range. In many instances, very little attention has been paid when installing irrigation systems to tree position in the grove. If proper irrigation controls have been installed, often trees on north and south aspects of a hill will be irrigated on the same schedule (personal observation).

Adding to this problem is soil depth changes from bottom of slope to top of slope. This changes the rooted volume and the moisture holding content. These changes in available soil moisture content in turn impact the irrigation schedule. Aside from having an impact on tree growth and productivity, improper irrigation is the main cause of a fungal disease, avocado root rot, which has spread throughout the industry (Coffey, 1987).

Slope effect on the microclimate determines the site atmospheric water demand, as it changes the net radiation load and may change the air temperature, air humidity and wind speed. The changes in radiation load with slope orientation and steepness are relatively simple corrections to available models (Dubayah, 1995). The changes in relative humidity, air temperature and wind speed are less regular and more difficult to predict as they involve 3-D micro topography effects (Burman and Pochop, 1994; Paltridge and Platt, 1976).

The objective of this work was to evaluate the extent of the relative difference in evaporative demand based on slope position in order to better inform growers of the need to manage their irrigation systems better.

Materials and Methods

A site for the trial was found at Pukehina, New Zealand at 38° south latitude on the North Island. The trial was established on a nearly round hill 96 m high with a circumference of approximately 2.5 km. Dairy cattle grazing on rain-fed pasture occurred on the hill and in a 1 km radius around the hill. The top of the hill was 2 km from the Bay of Plenty on the north side of the hill. Every month of the year there was rainfall ranging from 80134 mm per month. Winter temperatures average 10° C and summer averages 19°C. Total sunshine hours for the area are about 2,500 with an annual average of 14.1 megajoules sq.m^2. All day long there are winds which average 17 km/hr throughout the year. Daily average relative humidity at 9 a.m. is 78%.

Atmometers (ET Gage, C&M Meteorological Supply, Colorado Springs, CO) were placed in the open and monitored for 2 weeks to determine the variability there was in their readings. They were then attached to fence posts at the field site. They were placed in the four quadrants of the hill, at the toe, mid-slope and at the top of the hill, for a total of nine atmometers. On a monthly basis, readings were made and the chambers refilled with water. Atmometers were installed December 15, 1999 and readings were made in the first week of each month until August 8, 2000.

Results and Discussion

Finding a site for this study was difficult. Much of California is a Mediterranean climate, with a wet winter and a dry summer and fall. In the coastal areas where avocado is planted, the upwind area is often compromised by irrigated fields, buildings, dry lands, woodlands, etc. To make this study generalizeable, rather than site specific, it meant finding a hill with comparable fetch in all directions. This was found in a rain-fed pasture in New Zealand.

Atmometers were selected for this study because they are relatively inexpensive and integrate the various components that cause evaporation. After calibrating the nine atmometers for two weeks, it was found that the devices varied by 5% from the highest to the lowest reading.

When installing the atmometers in the field it was evident that wind was especially variable at the different slope positions, although no wind recordings were made. The atmometer readings are arranged from highest reading to lowest reading for the trial period (Table 1). Atmometers 8 and 9 with the lowest readings were in the lee of the hill and also on the southern hemisphere's shaded side. Atmometer 1 with the highest readings was at the crown of the hill. For the time period of the trial, atmometer 1 evaporated nearly 60% more water than the average of 8 an 9.

Atmometers 2–7 on the toe and mid-slopes of the hill faced more similar wind conditions, even though they were on different aspects. Lacking replication, these readings are considered intermediate between the high and low readings. On a monthly basis, there was some inconsistency in the atmometer 2-7 readings, depending on position (Fig. 1). For example in one month an atmometer at the toe of the slope would have a higher reading than the mid-slope on the same aspect and the next month their rankings would be reversed. This was possibly due to the uneven topography on the hill which could have affected wind patterns differently in different months. Or possibly that at the monthly additions of water there might have been improper seating of the one-way valve in the device. If the sites had been replicated properly it might have been possible to determine whether a west or east facing slope caused greater evaporative demand. Their readings, however, were always intermediate between atmometer 1 and atmometers 8 and 9. The atmometer at the top of the hill evaporated about 16% more of the averaged value of atmometers 2-7 for the total time period.

During the high evaporative season when light was least limiting around the hill, there was only a 32% difference between the highest and lowest readings. During the lowest evaporative period, there was nearly 120% difference. This great difference occurred when the sun was lowest on the horizon. The evaporative demand difference between a north and south slope is not constant from month to month and in an irrigated avocado grove in California this should be accounted for in the irrigation schedule.

The wind conditions, as well as the other climatic factors of high humidity and low temperature, make it difficult to directly apply these results to a California avocado grower's conditions. It does, however underscore the variability in evaporative loss depending on slope position and that growers should accommodate an irrigation schedule based on that knowledge. When designing an irrigation system, growers should build in enough flexibility so that they can irrigate according to the tree's needs. In this hypothetical case of a hill in New Zealand, the grower would need to have at least three different schedules to irrigate properly.

Literature Cited

Burman, R. and L.O. Pochop. 1994. Evaporation, evapotranspiration and climate data. Development of Atmospheric Sciences, 22; Elsevier.

Coffey, M.D. 1987. Phytophthora root rot of avocado. Am. Phytopath Soc. 71(11): 1046-1052.

Dubayah, R. and Rich, P.M., 1995. Topographic solar radiation models for GIS. Int. J. Geographical Information Systems, 9(4): 405-419.

Paltridge, G. W and C.M.R. Platt 1976. Radiative processes in meteorology and climatology. Development of Atmospheric Sciences, 5; Elsevier.

Staff report. 1982. Terracing steep grove saves valuable soil, experts claim. Avocado Grower. 6(5): 13-17.

Table 1. Evaporative loss from atmometers for total period December 15 –August 8. Atmometer 1 is on the top of the hill, 8 and 9 are on the lee side and 2 – 7 are at the toe and mid-slope.

Atmometer	Loss in mm
1	614
2	552
3	550
4	548
5	530
6	505
7	503
8	403
9	369

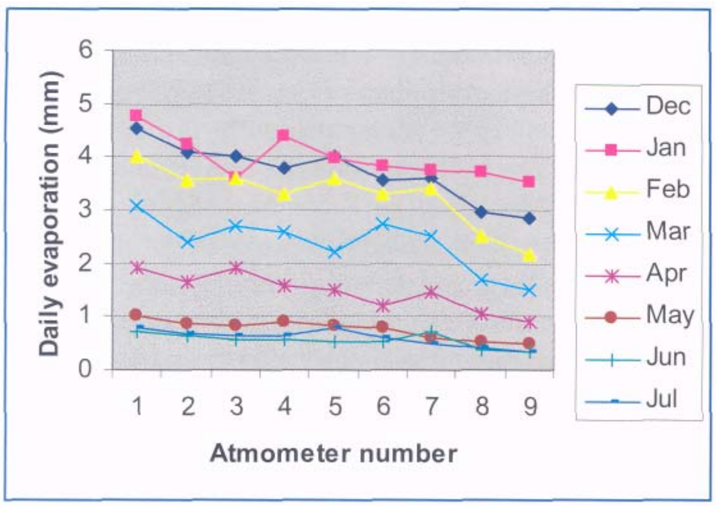

Figure 1. Monthly daily evaporation from nine atmometers on the southern hemisphere island of New Zealand. 1 is top of slope, 8 and 9 are from the lee of the hill, 2 -7 are from toe and mid-slopes.