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THE PATTERN OF SOIL WATER EXTRACTION BY

INDIVIDUAL KIWIFRUIT VINES

A thesis presented in partial fulfillment
of the requirements for the Master of Agricultural
Science in Soil Science at
Massey University

VALERIE OLGA SNOW

1987

ABSTRACT

In order to efficiently design and operate irrigation systems water balance studies are needed. To date few of these studies have been carried out on kiwifruit.

Detailed measurements of water extraction were made beneath two 7 year old kiwifruit vines. Under-vine covers were used on these vines to exclude rainfall and irrgation. Measurements of fruit size and leaf water potential were made on the two covered vines and on adjacent irrigated vines. In addition, solar radiation and air temperature were monitored in the orchard block. In concurrent studies, the root distribution of vines in the orchard were determined and heat pulse measurements of sapflow were made.

The water extraction pattern showed little variation with depth to the maximum depth of measurement (2.2 m). There was, however, considerable variation in extraction with horizontal distance away from the vine. This variation may be explained in terms of the root distribution. The soil volume may be divided into the zone of occupation, in which the soil is completely occupied by the plant roots, and the zone of exploration, which is the volume of soil in which there are a few roots but the soil is still largely unexplored. Within the zone of occupation, water is uniformly extracted despite variation in root density. Water appears to be extracted from the zone of exploration primarily by flow of water towards the zone of occupation, where the soil water potential is lower.

The fruit volume and leaf water potential measurements were used to indicate the onset of water-stress. At this time, soil water potential in the zone of occupation was between -40 and -50 kPa. The size of the reservoir of readily availible water was found to be at least 2.1 m^3 for 7 year old vines, and is projected to rise to a maximum of at least 6.5 m^3 in three or so years in this orchard. Whereas the vine canopy may, by management, mature in 3 years, the root system may take 10 years to mature, so irrigation requirements of young vines will be higher than for mature vines. This is contrary to common assumptions made in standard methods for designing horticultural irrigation systems and is due to

changes in the size of the reservoir rather than changes in the rate of water use.

When there is radial variation in water extraction it is important to take account of the variation when calculating volumes of water extracted from the soil. The rate of water use by the vines, as estimated by the water balance method and the heat pulse technique, was found to be considerably lower than that predicted by the equilibrium evapotranspiration rate. This may be due to experimental error, and further work is required to clarify this matter.

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The research presented in this thesis was a part of a larger investigation into the water economy of kiwifruit. People involved in this research have included Brent Clothier, Steve Green, Tom Sauer, Paul Gandar, Keith Hughes and Howard Nicholson. Thanks are specially due to Brent Clothier, Steve Green and Tom Sauer for assistance with some of the measurements presented in this thesis.

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		units
a	fitted constant	
b	fitted constant	
C_r	count rate	counts s^{-1}
E	rate of water vapourisation	mm day^{-1}
ET	rate of evapotranspiration	mm day^{-1}
k	hydraulic conductivity	m s^{-1}
NS	not significant	
NZDT	N. Z. daylight time	
R_n	net radiation	MJ m^{-2} day^{-1}
r	radius	m
s	slope of saturation vapour curve	mPa $°C^{-1}$
sd	standard deviation	
TDR	time doman reflectometry	
t	time	s
z	depth	m
γ	psychrometric constant	mPa C^{-1}
Δ	change with time	
ε	total error on θ	m^3 m^{-3}
ε_c	calibration error on θ	m^3 m^{-3}
ε_i	instrument error on θ	m^3 m^{-3}
ε_l	location error on θ	m^3 m^{-3}
ε_s	site error on θ	m^3 m^{-3}
θ	volumetric soil water content	m^3 m^{-3}
θ_m	measured value of θ	m^3 m^{-3}
θ_t	true value of θ	m^3 m^{-3}
λ	latent heat of vapourisation	MJ kg^{-1}
ρ_b	soil bulk density	Mg m^{-3}
ψ	soil water potential	kPa
ψ_l	leaf water potential	MPa
ω	gravimetric soil water content	kg kg^{-1}