Partial rootzone drying in apple and in processing tomato

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Abstract

New water saving irrigation strategies need to be explored and partial rootzone drying (PRD) is such a strategy as it involves irrigating only part of the rootzone with the complement left to dry to a pre-determined level. In other deficit irrigation (DI) methods the entire rootzone is irrigated with less water than evapotranspiration. I focussed on PRD for its effects on apple and on processing tomato.

For apple three field experiments were done, two on 'Pacific Rose™' in Manawatu and one on 'Royal Gala' in Hawke's Bay. In all three, leaf water potential (Ψ_{leaf}) was similar between PRD and commercially irrigated (CI) treatments and so were yield and fruit quality. However, 'Pacific Rose™' PRD fruit in one experiment had lower water loss in storage than did CI fruit. For 'Royal Gala', PRD fruit quality was improved in terms of flesh firmness and total soluble solids concentration. In all apple experiments PRD trees received only 50% of water given to CI trees. I recommend PRD as a feasible irrigation strategy for apples in New Zealand, but suggest further research for drier areas.

'Petopride' tomato was studied in six glasshouse experiments. Depending on the experiment, PRD irrigation was shifted to the previously-unwatered rootzone on the basis of volumetric soil water content, on a daily basis, and on intervals of 2, 4, and 6 days. Maintenance of Ψ_{leaf}, photosynthetic rate, stomatal conductance, yield, and fruit quality in PRD depended on the extent of soil drying. Irrigation use efficiency was almost twice higher in PRD plants than in CI plants. Blossom-end rot was higher in some of the PRD treatments, but in an especially-designed experiment I found out that PRD *per se* could not be the cause. From an experiment involving the measurement of root water potential, I concluded that water does not move from the wet roots to dry roots during PRD. I found that the tomato fruit, which is normally a stronger sink than vegetative parts, becomes a weaker sink during water stress. I recommend PRD for processing tomato, but with a suitable irrigation frequency to avoid lowering the midday Ψ_{leaf} to a value of less than –1.2 MPa. This necessitates field trials in various environmental conditions.

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A	Photosynthetic rate
ABA	Abscisic acid
BER	Blossom-end rot
°C	Degree Celsius
ca	Approximately
Ca^{2+}	Calcium
CANDISC	Canonical discrimination analysis
CDF	Canonical discriminant function
CI	Commercially irrigated
DAA	Days after anthesis
DAS	Days after seeding
DAH	Days after harvest
DAFB	Days after full bloom
DI	Deficit irrigation
DMCF	Dry mass concentration of fruit
E	Transpiration rate
FC	Field capacity
FD	Fruit diameter
Fden	Fruit density
FF	Flesh firmness
FI	Fully irrigated
FSG	Final shoot growth
FV	Fruit volume
FWC	Fruit water content
FWL	Fruit water loss
g	Gram (s)
GLM	General linear model
g_s	Stomatal conductance
HA°	Hue angle
IEC	Internal ethylene concentration
ITs	Irrigation treatments
IUE	Irrigation use efficiency
$IUE_{(TFMF)}$	Irrigation use efficiency on the basis of total fresh mass of fruit
$IUE_{(TDMF)}$	Irrigation use efficiency on the basis of total dry mass of fruit
HI	Harvest index
Hr	Hour (s)
kg	Kilogram (s)
L	Litre
LSD	Least significant difference
µL	Microlitre (s)
µmol	Micromole (s)
m	Metre (s)
mb	Millibar (s)

m^3	Cubic metre (s)
min	Minute
Mg^{2+}	Magnesium
Mg	Milligram (s)
mm	Millimetre (s)
MFMF	Mean fresh mass per fruit
MSD	Minimum significant difference
N	Newton (s)
ns	Non-significant
NF	Number of fruit
P	Probability
P_a	External CO_2
Pi	Internal CO_2
PPF	Photosynthetic photon flux
PRD	Partial rootzone drying
PSRE	Potted split-root experiment (s)
RS	Root system
RWC	Relative water content
RWCR	Relative water content of root
SAS	Statistical Analysis System
SCC	Standardised canonical coefficients
SCS	Standardised canonical scores
SCSA	Shoot cross-sectional area
SD	Standard deviation
SEM	Standard error mean
SPAC	Soil-plant-atmosphere-continuum
SPI	Starch patter index
SRS	Split-root system
TM	Trade mark
TCSA	Trunk cross-sectional area
TFMP	Total fresh mass of plant
TDMP	Total dry mass of plant
TFMF	Total fresh mass of fruit
TDMF	Total dry mass of fruit
TSSC	Total soluble solids concentration
WD	Water deficit
W/D.	Wet/Dry
W/D/W/D	Wet/Dry/Wet/Dry
θ	Volumetric soil water content ($m^3 m^{-3}$)
Ψ	Water potential
Ψ_s	Osmotic potential
Ψ_P	Turgor potential