FRUIT QUALITY AND COMPOSITION, GROWTH, WATER RELATIONS, AND POSTHARVEST PERFORMANCE OF 'BRAEBURN' APPLES (*Malus Domestica* BORKH.) UNDER REDUCED IRRIGATION

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By
ANTHONY W. KILILI

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ABSTRACT

Benefits of reduced irrigation in apple production include decreased costs, control of vegetative growth, possible improvement in fruit quality, and reduced leaching of nutrients and pesticides into ground water. This study was on the effects of withholding irrigation at different times of the growing season on water relations, photosynthesis, growth, fruit quality and composition, and postharvest performance of 'Braeburn' apples (*Malus domestica* Borkh.).

Seven-year-old trees on MM. 106 rootstock were subjected to four irrigation treatments in a randomized complete block design. The treatments were: fully watered control (C); early withholding (EW) of irrigation from full bloom until 104 days after full bloom (DAFB); late withholding (LW) of irrigation from 104 DAFB up to final harvest at 194 DAFB; and nonirrigated (NI), where trees were not irrigated during the entire growing season.

Trees not receiving irrigation at any stage developed a lower predawn and midday leaf water potential relative to the well-watered control. For LW and NI trees towards the end of the growing season, water stress caused a reduction in the rate of photosynthesis (*Pn*), stomatal conductance (g_s), and the rate of transpiration. The reduction in *Pn* was caused by non-stomatal factors in addition to a reduction in g_s. Withholding irrigation caused an increase in canopy temperature and canopy-air temperature difference in LW and NI possibly due to the reduction in the rate of transpiration.

Fruit growth and fruit growth rate measured from 42 DAFB up to harvest were not affected by the treatments although shoot growth and increase in trunk circumference were significantly reduced by withholding irrigation during the early and entire season. Mean fruit weight at harvest and return bloom were reduced in EW and NI relative to C and LW. The treatments had no effect on total yield per tree, crop density or yield efficiency.

At final harvest, total soluble solids, soluble sugars (fructose, sucrose, and sorbitol), flesh firmness, and red skin colour intensity were higher in NI and LW than in C. The concentration of glucose and minerals (N, P, Ca^{2+}, Mg^{2+}, and K^{+}) in the fruit was not affected by the treatments.

Withholding irrigation during the late and entire growing season resulted in more advanced fruit maturity as indicated by an earlier ethylene climacteric, more yellow background skin colour, and increased total soluble solids concentration. Firmness remained higher in LW and NI than in EW and C during a 12-week storage period at 1 °C. Weight loss was higher in C than in the reduced irrigation treatments. Skin permeance to water vapour was higher in C relative to EW and NI.

This study showed that withholding irrigation late in the season may be used in apple production with improved fruit quality in terms of increased total soluble solids, firmness, soluble sugars, and intensified red skin colour without adverse effects on fruit size and yield. For the control of vegetative growth, withholding irrigation early in the season is best but this treatment may adversely affect fruit size. Reduced irrigation is also potentially beneficial in terms of reduced weight loss and increased firmness in storage.

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GLOSSARY OF ABBREVIATIONS

A	- Surface area of the fruit (m^2)
ACC	- 1-aminocyclopropane-1-carboxylic acid
ANOVA	- Analysis of variance
C	- Control
CD	- Crop density (g of fruit per unit trunk cross sectional area)
C_a	- External CO_2 concentration ($\mu mol\ mol^{-1}$)
C_i	- Intercellular CO_2 concentration ($\mu mol\ mol^{-1}$)
DAFB	- Days after full bloom
ET	- Evapotranspiration
EW	- Early withholding of irrigation
FGR	- Fruit growth rate ($mm\ day^{-1}$, $g\ day^{-1}$, or $cm^{-3}\ day^{-1}$)
Ft_1	- Fruit size at time 1 (mm, cm^{-3}, or g)
Ft_2	- Fruit size at time 2 (mm, cm^{-3}, or g)
FW	- Initial fresh weight
GLC	- Gas liquid chromatography
GLM	- General linear models
g_s	- Stomatal conductance ($mol\ CO_2\ m^{-2}\ s^{-1}$)
H	- Hue angle (°)
HPLC	- High performance liquid chromatography
IR	- Infrared
L	- Lightness (%)
LW	- Late withholding of irrigation
MPa	- Mega Pascal (1 MPa = 10 bars)
n	- Number of observations
NI	- Nonirrigated
PAR	- Photosynthetically active radiation ($\mu mol\ quanta\ m^{-2}\ s^{-1}$)
Pn	- Rate of photosynthesis ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)

P'_{H2O} - Skin permeance to water vapour (mol s^{-1} m^{-2} Pa^{-1})

RCBD - Randomized complete block design

RDI - Regulated deficit irrigation

RH - Relative humidity (%)

r'_{H2O} - Rate of water loss (mol s^{-1})

SAM - S-adenosylmethionine

SEM - Standard error of the mean

T - Rate of transpiration (mmol m^{-2} s^{-1})

TA - Titratable acidity (% malic acid)

T_a - Air temperature (°C)

T_c - Canopy temperature (°C)

T_c-T_a - Canopy-air temperature difference (°C)

T_1 - Time 1 (day)

T_2 - Time 2 (day)

TCA - Trunk cross-sectional area

TDR - Time domain reflectometry

TSS - Total soluble solids

θ - Soil volumetric water content (m^3 m^{-3})

VPD - Vapour pressure deficit (kPa)

VP_{air} - Actual water vapour pressure (kPa)

VP_{sat} - Water vapour pressure at saturation (kPa)

YE - Yield efficiency (g of fruit cm^{-2} TCA)

Ψ - Leaf water potential

LIST OF FIGURES