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Short communication
Mineral contents of grape, olive, apple, and tomato under reduced irrigation

Kurzmitteilung
Mineralstoffgehalte von Weintrauben, Oliven, Äpfeln und Tomaten bei reduzierter Bewässerung

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1 Introduction

Deficit irrigation (DI) involves supplying less water to plants than evapotranspiration (ET), and the water is given to the entire rootzone. Partial rootzone drying (PRD) involves wetting only part of the rootzone at each irrigation with the complement left to dry to a pre-determined level. Both DI and PRD have advantages which include saving of water, less irrigation costs, reduced leaching of nutrients and biocides past the rootzone, and reduced growth of deciduous fruit trees lowering pruning costs (*Behboudian* and *Mills*, 1997). There is also the possibility of improving fruit quality in some respects (*Zegbe-Domínguez* et al., 2003). One possible disadvantage is a reduction in fruit mineral concentration which is an important fruit quality attribute. For example, deficiency of Ca^{2+} causes physiological disorders of blossom-end rot in tomato and bitter pit in apple (*Bangerth*, 1979). Because PRD is a new irrigation technology, information about its effects on fruit mineral nutrition is lacking, and for DI the existing information is contradictory and inconclusive. The objective of this research was to obtain conclusive information on the effect of DI and PRD on leaf and fruit mineral nutrition of four plant species.

2 Materials and methods

2.1 Grape and olive experiments

These were conducted during the 2001–2002 growing season in Marlborough (latitude 41° 30′ S, longitude 173° 55′ E), New Zealand. 'Sauvignon Blanc' grape was either commercially irrigated (CI) with 100 % replacement of ET or DI at 60 % of ET. The CI treatment for 'Barnea' olive received 100 l tree^{-1} weekly and the DI treatment received 1/3 of CI.

2.2 Apple and tomato experiments

These PRD experiments were conducted in the 2001–2002 growing season at Massey University, Palmerston North (latitude 40° 2′ S, longitude 175° 4′ E). The CI treatment of 'Pacific Rose™' apple was irrigated five times, with a total of 344 l tree^{-1}, during the growing season. One side of the PRD trees was irrigated with half the volume of water given to CI and the other side was left to dry to volumetric soil water content of 0.18 to 0.22 $m^3\ m^{-3}$ before irrigation being shifted to this side. The CI treatment of 'Petopride' processing tomato, grown in a glasshouse, received 130 l plant^{-1} for the whole season. The PRD treatment was irrigated on one side of the rootzone with half the amount of water received by CI. The other side was allowed to dry until the next irrigation which happened the following day.

Leaf water potential (LWP) was measured using a Scholander pressure bomb, and the soil volumetric water content was measured using time domain reflectometry. The total N and P in fruit and leaf samples was determined using a Technicon colorimetric analyzer following Kjeldahl digestion. Fruit and leaf samples were digested with concentrated nitric acid for the determination of Mg^{2+}, Ca^{2+}, and K^+, using an atomic absorption spectrometer (AAS: model GBC 904AA). The data were analyzed using the GLM procedure of Statistical Analysis System (SAS) software version 8.2. Treatment means were separated by t-test at $P \leq 0.05$.

3 Results and discussion

Leaf and fruit nutrient concentration was generally unaffected by irrigation treatment (Tab. 1), although soil water content was significantly higher in CI than the corresponding DI or PRD treatments (data not shown). The lower soil water status was not reflected in the LWP for grape because both CI and DI treatments had a predawn value of –0.23 MPa. For apple and tomato, the CI treatments had a higher midday LWP than the PRD treatments. For apple, the CI and PRD values were, respectively, –0.56 and –0.65 MPa. The corresponding

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Table 1: Effect of commercial irrigation (CI), deficit irrigation (DI), and partial rootzone drying (PRD) on leaf and fruit nutrient concentrations (mg (g dry weight)$^{-1}$) of grape, olive, apple, and tomato at harvest. NS indicates non-significant differences at $P \le 0.05$. We lack data for potassium concentration in tomato leaves.

Tabelle 1: Einfluss der Bewässerung auf die Mineralstoffgehalte (mg (g Trockenmasse)$^{-1}$) in den Blättern und Früchten von Weintrauben, Oliven, Äpfeln und Tomaten. NS bedeutet: nicht signifikant bei $P \le 0{,}05$. Kaliumgehalte in den Tomatenblättern stehen nicht zur Verfügung.

	Leaf					Fruit				
	N	P	Mg^{2+}	Ca^{2+}	K^+	N	P	Mg^{2+}	Ca^{2+}	K^+
Grape										
CI	16.1	2.0	2.9	21.2	14.5	5.2	1.2	0.5	1.5	8.9
DI	15.2	2.4	3.6	20.4	13.9	5.4	1.2	0.5	1.2	8.9
Significance	NS	NS	NS	NS	0.01	NS	NS	NS	NS	NS
Olive										
CI	18.5	1.2	1.6	21.9	7.7	6.3	1.3	0.4	1.0	21.1
DI	17.7	1.2	1.5	19.9	7.5	6.8	1.2	0.4	1.2	17.2
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.04
Apple										
CI	18.8	1.6	3.1	15.4	8.6	3.1	0.8	0.3	10.0	8.6
PRD	19.0	1.7	2.9	15.4	9.3	3.5	0.8	0.3	9.1	9.3
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Tomato										
CI	33.2	7.8	6.2	43.3	–	19.8	5.0	2.6	1.8	38.0
PRD	32.6	7.0	5.9	41.4	–	17.8	4.2	2.4	2.0	38.8
Significance	NS	NS	NS	NS	–	NS	NS	0.03	NS	NS

values for tomato were –0.38 and –0.48 MPa. LWP was not measured for olive. Irrespective of LWP, Tab. 1 shows that the pattern of nutrient concentration in leaf and fruit was the same among the four species and was not affected by irrigation. Potassium was the only element showing a decrease in concentration in grape leaf and in olive fruit. This reflects the possible effect of a reduced transpiration rate. The effect of reduced irrigation on fruit nutrient concentration may depend on the degree of water deficit imposed. We would therefore expect different responses if a more severe water deficit were imposed. However, in a horticultural production system a more severe deficit is not justified because we have already saved water by 40 %, 66 %, 50 %, and 50 % for grape, olive, apple, and tomato, respectively. We therefore conclude that the advantages of DI and PRD in horticultural production could be realized without any deleterious effects on fruit mineral nutrition.

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