The Response of Grapevines to Transient Soil Salinisation

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ABSTRACT

Colombard grapevines on Ramsey rootstocks were irrigated with saline water, with an electrical conductivity (EC) of 3.5 dS/m during any one of the four stages within the seasonal growth of mature grapevines. Saline water was produced by addition of a sodium chloride brine to River water (EC 0.6 dS/m). Periods of salinisation and treatment designation were as follows: the treatment salinised between bud-burst and full-bloom was designated BB-FB; that between full-bloom and veraison - FB-V; that between veraison and harvest - V-H; that between harvest and leaf-fall - H-LF. At other times these treatments were irrigated with river water. A control, designated CONT, was irrigated with river water throughout the season.

Over a single season, saline irrigation of immature grapevines in any period reduced shoot growth by an equivalent amount, 12% on average. During saline irrigation, leaf water potential (Ψ_l) was reduced by 0.15 MPa. Leaf Na and Cl concentrations rose in response to saline irrigation and remained elevated.

In mature field grapevines, saline irrigation over three consecutive seasons had no effect on either the pruning weights or the butt enlargement. Yield only declined in treatment FB-V, and then only in the second season. The decline of 6% was entirely due to a reduction in the weight of berries.

Measurements of Ψ_l made during the second consecutive season of saline irrigation showed that Ψ_l fell by between 0.05 and 0.15 MPa during saline irrigation. Leaf Cl concentrations rose with ECw. However, the rises in leaf Na did not necessarily bear any relationship with those in the ECw.

Saline irrigation affected the juice composition in all three seasons and by the second season it increased the concentrations of malate, tartrate and potassium, and increased the pH and titratable acidity of all treatments. Saline irrigation did not affect juice total soluble solids (°Brix).

It was concluded that during periods of high water salinity in the River Murray, vignerons would gain the most benefit from non-saline dilution flows released between mid-November and mid-January, and that the response of mature vines could not be predicted from the results of the experiment with immature vines.

SUMMARY

The response of Colombard grapevines on Ramsey rootstocks to transient soil salinisation was studied in immature potted grapevines for a single season and for three seasons in mature field grapevines growing under favourable productive conditions. Five treatments were applied; four consisted of irrigating with saline water during one of the four stages within the seasonal growth of mature grapevines. River water, with an electrical conductivity (EC) of about 0.6 dS/m, was salinised by the addition of a sodium chloride brine which increased the EC to 3.5 dS/m. Periods of salinisation and treatment designation were as follows: the treatment salinised between bud-burst and full-bloom was designated BB-FB; that between full-bloom and veraison - FB-V; that between veraison and harvest - V-H; that between harvest and leaf-fall - H-LF. At other times these treatments were irrigated with river water. A control, designated CONT, was irrigated with river water throughout the season.

In immature grapevines, saline irrigation in any period reduced shoot growth by an equivalent amount, 12% on average. Most of this reduction occurred during the application of saline irrigation. The fall in growth was equivalent to that reported in a study with Sultana on Ramsey rootstock where the same annual salt load was evenly distributed across the entire season.

During saline irrigation, leaf water potential (Ψ_l) was reduced by 0.15 MPa. This reduction bore a near one-to-one relationship with the fall in the osmotic potential of the irrigation water suggesting the electrical conductivity of the soil solution (ECsw) was equivalent to that of the irrigation water (ECw). Leaf Na and Cl concentrations rose in response to saline irrigation. The maximum concentrations were 228 and 280 mmol/kg for Na and Cl, respectively. Concentrations of Na and Cl remained elevated after saline irrigation ended.

In mature vines, the irrigation was scheduled to replace water as it was used by the grapevines. This schedule produced a variation in the volume of water

applied in each growth stage and a variation in the amount of salt applied per season in each treatments. Had the salt load, which was applied in a two month period, been evenly spread across the season then the ECw in treatments V-H, FB-V, H-LF, and BB-FB would have been 1.7, 1.6, 0.9, and 0.8 dS/m. After two months of saline irrigation, the electrical conductivity of the saturated soil paste extract (ECe) rose to about that of the irrigation water, 3.5 dS/m. Changes in the ECe lagged behind those in the ECw. Because of this lag the ECe of the rootzone displayed large variations with depth.

In the second consecutive season of saline irrigation, Ψ_l fell by between 0.05 and 0.15 MPa during saline irrigation. The fall had a near one-to-one relationship with the fall in the osmotic potential of the saturated soil paste extract suggesting ECe was equivalent to ECsw. Leaf Cl concentrations rose with ECw. However, the rises in leaf Na did not necessarily bear any relationship with those in the ECw: in BB-FB, leaf Na did not rise until one month after the end of saline irrigation and in V-H it rose two months before the beginning of saline irrigation. The rise in the leaf Na of V-H occurred whilst its ECe was equivalent to that in the control treatment suggesting that Na was carried over within the vine from the previous season. The concentrations of Na and Cl in the March sample of the leaf lamina and grape berry juice were normalised to remove the effect of differences in the annual salt loads between treatments. This transformation showed that the greatest rate of Cl uptake per unit increment in annual salt load occurred in the leaf in the treatment BB-FB and in the grape in treatments BB-FB and FB-V. Uptake rates of Na into the leaf and grape were equivalent in the three treatments which received saline irrigation before harvest.

As the season advances the Cl uptake rate by the berry declines. In combination with a relatively constant Na uptake rate this caused an increase in the ratio of Na to Cl. As a result saline irrigation between full-bloom and veraison in the second season and between veraison and harvest in the second and third seasons produced juice where the excess of sodium over chloride ions was above that acceptable in wine destined for the EEC.

Over three consecutive seasons, saline irrigation had no effect on either the pruning weights or the butt enlargement. Yield only declined in treatment FB-V, and then only in the second season. The decline of 6% was entirely due to a reduction in the weight of berries, however a decline in berry weight did not necessarily lead to a reduction in yield. In the third season, berry weight declined in the three treatments which received saline irrigation before harvest. Normalisation of these data to remove the difference in the annual salt loads between treatments showed that the greatest reduction occurred in treatment BB-FB.

The yield data was conservatively adjusted to allow comparison with results reported in a study on the response of own-rooted Sultana to a saline irrigation regime where the annual salt load was evenly distributed across the season. The comparison showed that the yield savings gained by constraining the annual salt load to a two month period within the season were in the order of 10%. It was hypothesised that constraining saline irrigation to a two month period within the season created opportunities for the vine to avoid salt stress.

Saline irrigation affected the juice composition in all three seasons and by the second season it increased the concentrations of malate, tartrate and potassium, and increased the pH and titratable acidity of all treatments. Saline irrigation did not affect juice total soluble solids (°Brix). When the changes in composition were normalised to remove the difference in annual salt load between treatments the greatest increase in the concentrations of malate, tartrate and potassium, and in the titratable acidity, occurred in treatment BB-FB.

In models of the effect of salinity on the growth of grapevines it has been assumed that an equilibrium exists between the concentration of salt in the irrigation water and soil solution, and that under this condition the ratio in the pot between ECw and ECsw is 1:1 and in the field between 3:1 and 5:1. Therefore irrigation of a potted immature vine with water of ECw 3.5 dS/m should create conditions which equate to an ECsw in the field of between 0.7 and 1.2 dS/m. Given that ECsw in the field was threefold greater than 1.2 dS/m after two months of saline irrigation, the growth loss in potted vines should have under-estimated the loss found in field vines. Instead it over-estimated the loss. In the present study, the rapid turnover of soil water in pots quickly established an equilibrium between the ratio of ECw:ECsw with a value of 1:1. In contrast, turnover of soil water in the field was slower and although the ratio of ECw:ECsw rose over the two months of saline irrigation it only just reached 1:1 at the end of this period. These results indicate that, with an irrigation regime which constrains saline irrigation to a two month period within the season, the assumption regarding the ratio of ECw:ECsw which is used in the modelling of grapevine response to salinity does not apply.

Up to 40% of the vine's annual irrigation requirement can be met with water of EC 3.5 dS/m without loss of yield. Saline irrigation between full-bloom and veraison reduces yield, however the loss is much less than that predicted had the same annual salt load been spread evenly across the season. During periods of high water salinity in the River Murray, vignerons would gain the most benefit from non-saline dilution flows released between mid-November and mid-January. Further the results suggest that in seasons with a high annual salt load, damage can be reduced by selecting a strategy which concentrates the annual salt load into a two-month period over a strategy which evenly spreads the annual salt load over the entire season. Timing of saline irrigations affects the levels of free sodium in the juice and this level rose above that acceptable in wine destined for export to the EEC. The sensitivity of juice composition to salinity was greater than that of yield or berry weight. Changes in composition were not secondary effects of salinity induced changes in maturity or berry volume. The response of mature vines could not be predicted from the results of the experiment with immature vines.

Abbreviations and Symbols

BB	Bud-burst
FB	full-bloom
V	veraison
H	harvest
LF	leaf-fall
CONT	control treatment
EC	electrical conductivity
ECe	EC of a saturated soil paste extract
RWECe	root-weighted **ECe**
ECi	EC of irrigation water
ECw	EC of water from irrigation and precipitation
ECsw	EC of water in the soil solution
Ψ	water potential
Ψ_s	potential of water in the soil
Ψ_l	potential of water in the leaf
Ψ_π	osmotic potential
$\Psi_{\pi l}$	osmotic potential in the leaf
$\Psi_{\pi s}$	osmotic potential of soil solution
$\Psi_{\pi w}$	osmotic potential of irrigation water
τ	matric potential
G	gravitational potential
P	pressure
P_l	pressure in the leaf
π	osmotic pressure
π_l	osmotic pressure in the leaf
RWF	root-weighting factor
RLD	root length density
ETo	reference crop evapotranspiration
RWC	relative water content
TSS	total soluble solids.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

SIGNED: DATE: 1/2/96

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