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Use of saline irrigation water to increase total soluble solids in irrigation water

VG004

Dr PS Cornish

NSW Agriculture

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CONTENTS

1.	**Project Title:**	'Use of saline irrigation water to increase total soluble solids in irrigation water'
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SYNOPSIS:

This project assessed the feasibility of irrigating processing tomatoes with saline water as a way of increasing profit and also as part of a salinity management strategy. The results obtained in the project demonstrate that irrigation with slightly saline water should be a viable crop management strategy.

The profitability of growing and processing tomatoes depends on the concentration of total soluble solids (TSS) in the fruit. Earlier work at Gosford with table tomatoes had suggested that mild salt stress could increase TSS without necessarily reducing fruit yield. This suggested that irrigation of processing tomatoes with slightly saline water may be a way to improve profitability.

Aims of this project were:

1. to confirm if processing genotypes respond to salt in the same way as table tomatoes;

2. to select responsive cultivars for more extensive testing; and

3. to determine the timing and degree of salt stress that most reliably increases solids yield per hectare.

   The above work was undertaken under controlled conditions at Gosford using hydroponic culture and with field studies using a rain shelter.

4. A final aim was to test whether saline irrigation gives the desired responses in the production area (at Tatura). This field experiment was run by Mr. W. Ashcroft, Centre for Sustainable Agriculture.

Cultivars:

Eight cultivars were compared for their response to salt stress in both hydroponics and in the field over three years. All cultivars responded to saline stress by increasing TSS in fruit. This increase in TSS was partially offset by a decrease in fruit yield.

These responses were in the same direction as in table tomatoes. However, the two types differed with respect to the *shape* of the relationship between yield and TSS under rising salinity. Table tomatoes exhibited a plateau at low salinity, ie. as salt stress increased, there was initially no effect on yield although TSS increased. In processing cultivars, yield mostly declined linearly with a small increase in salinity, leading to a trade-off between TSS and fruit yield.

Only rarely, however, did salt stress *reduce* solids yield (TSS x fruit yield).

Some cultivars appeared to be either more responsive than the average in terms of TSS or less responsive in yield. The outcome is that cvv. Brigade, UC82B and 6203 responded well to salt stress, in terms of solids yield, but Alta, FM785 and Shasta apparently responded less well.

It is not known why the difference occurred between processing and table types, and possibly between processing types. However, timing and degree of stress were key factors in achieving a good response (see below).

Timing and degress of stress:
A series of three field experiments used a rainout shelter to exclude unwanted rainfall and provide control over salt stress. These experiments showed:

1. that saline irrigation water always increased TSS; and

2. there was no effect of saline water on fruit yield EXCEPT:

   - when constant salt stress was suddenly imposed before mid flowering with irrigation water and soil solution both >8 mS/cm;

   - when steadily rising stress, commencing in mid flowering (irrigation water EC = 8 mS/cm), resulted in soil solution increasing to EC>11 mS/cm by harvest; or

   - when rising stress applied before flowering (irrigation water EC = 4 mS/cm) resulted in soil solution increasing to about 5 mS/cm by mid flowering and 10 mS/cm by harvest.

Overall, the results showed that :

- **An increase in solids yield of about 10% seems to be possible. There is little risk of reduced solids yield because any reduction in fruit yield is offset by the increase in TSS.**

- **Later stress generally is safer than early stress.**

- **Rising stress is best, provided soil solution EC (from suction samplers) does not exceed about 6 mS/cm at maturity.**

These conclusions at Gosford are supported generally by the work at Tatura where, despite variability in the data, cv. UC82B appeared to give better responses than cv. Alta, and there appeared to be either an increase or no change in solids yield under salt stress, depending upon treatment.

This project achieves its goal by demonstrating the potential for saline irrigation to increase TSS and solids yield and therefore to increase returns to growers. The work also provides a guide to the irrigation strategies which are most likely to give the desired response.

Clearly, however, the benefit to growers will depend on the size of the bonus paid for higher TSS. Also, the bonus will need to be uncapped, as some new cultivars which are naturally high in TSS appear to respond well to salt stress resulting in very high TSS.

Further work is needed on varieties and the degree of salinisation that works best. Also, and most importantly, use of saline water needs to be developed as part of an overall salt management strategy in which choice of soil type, crop rotations and use of gypsum may be important to maintain soil structure.

BACKGROUND TO PROPOSAL:

The tomato processing industry faces stiff competition from imports so processing costs must be held low. The TSS of fruit is a major determinant of processing costs. In order to encourage production of fruit with higher TSS, processors pay a premium (or penalty) of $2 per tonne per 0.1° brix above (or below) a mean value. It is therefore in the financial interests of both processors and growers to increase TSS.

In California and Israel, research with processing tomatoes has shown that established tomato plants are relatively tolerant to salt and that strategic applications of saline irrigation water can increase TSS by up to 0.5° brix with little affect on yield. The emphasis in this work has been on the safe re-use of saline water, not on the development of strategies to increase TSS although such work is now current in the USA.

In Europe and the UK, fresh market tomatoes are commonly grown in hydroponic solutions with electrical conductivity (EC) as high as 8.0 mS/cm specifically to increase TSS. EC is a measure of the solute concentration in water, and includes both nutrients and salts such as sodium chloride (NaCl).

At Gosford on the Central Coast of New South Wales, field research with fresh-market tomatoes has shown that high EC in irrigation water (up to 8 mS/cm) can, in the absence of leaching rainfall, increase TSS by up to 0.5° brix (Cornish and Nguyen 1989). Unfortunately, high rainfall on the coast, together with freely-draining soil, means that high soil solution EC is difficult to maintain. In hydroponics, where solution EC is easy to maintain, tomatoes grown outdoors gave an increase in TSS of 0.5° brix with no yield loss at EC's of 4 - 6 mS/cm (control = 2 mS/cm), depending upon weather conditions (Cornish 1992).

There is therefore reasonable evidence from Australia and overseas that salt stress can increase TSS without necessarily decreasing yield. In the irrigation areas of New South Wales and Victoria, where saline groundwater and drainage water is available, the technique of strategic irrigation with saline water could be an attractive means of increasing TSS as well as reducing irrigation costs (as less channel water is used). It would also make a contribution to salinity management. Irrigation of pastures using saline water is being developed as a salt management strategy, and there is a need for crops which can also fit into this strategy. Tomatoes are a good candidate.

Before saline irrigation could be adopted by the industry, it would be necessary to show that fruit yield was not reduced or, at least, that solids yield per hectare (yield x TSS) was increased. Also, that this increase could be achieved without risk to either the crop or to soils. As other research already addresses soil aspects of saline irrigation, this project focussed on the plant aspects of irrigation with saline water.

OBJECTIVES:

This project assessed the feasibility of using controlled salt stress to increase TSS. Specifically, it sought to confirm effects of mild salinity on TSS and yield, examine responses by a range of cultivars, and provide information on salt concentrations and timing of stress for later field testing.

METHODOLOGY:

Hydroponics: In one series of two experiments, hydroponic culture in the outdoors at Gosford was used to provide a well controlled salt and nutritional regime for plants to grow in.

This series of experiments compared cultivars for their response to six concentrations of salt up to 12 mS/cm, about one-third the concentration in seawater. NaCl was added to standard nutrient solution (2 mS/cm) to achieve the desired EC. Treatments were replicated four times, with EC main plots split for cultivar.

Plants were grown in standard nutrient solution until the first fruit set were about 2 cm diameter. Salt treatments then commenced. Each day the nutrients required by the control treatment (EC = 2 mS/cm) were added to all treatments, and then EC was brought to the nominal treatment value with NaCl. Solutions were replaced twice during fruit development.

The split plot design meant that cultivars varied in the physiological stage at which salt treatment commenced. This may explain some of the cultivar differences.

A third experiment in hydroponics (outdoors) compared a table cultivar (Flora Dade) with a processing cultivar (H31) and similar comparisons were made in glasshouse studies using hydroponics.

The experiments outlined above were also used to make introductory studies of physiological responses to salt stress: plant water relations, leaf temperature, leaf photosynthetic rate and carbon partitioning, with the aim of elucidating the reason for differences between cultivars and to explain how salt stress can, in some cultivars at least, increase the solids concentration in fruit and not reduce total fruit fresh weight, ie. how can stress result in *greater* total assimilate in fruit?

Field experiments: These were conducted in sandy podzolic soil at Gosford using a mobile shelter (covered in plastic sheeting) to cover plots during rainfall. The shelter was not operational in the first year (1989/90). All plots had subsoil drainage at 1 m depth.

These experiments were also used to test genotypic responses under field conditions, but using fewer salt treatments than in hydroponics. Other studies focussed on the timing and degree of salt stress.

Two contrasting strategies for soil salinisation were used. One relied on replacement of soil solution with salt solution of the desired EC. At the appropriate physiological stage, crops were irrigated to excess with water at the treatment EC. Suction samplers were used to recover soil water from the root zone which was flushed with salinsed water (or untreated water in controls) until the desired EC was obtained. Soil solution EC was then maintained by irrigating with water of the correct EC as required. This method was used when comparing genotypes and for two studies on timing and degree of stress.

The alternative approach, which sought to mimic probable salinisation patterns under commercial conditions, employed an irrigation strategy designed to match water supply with crop demand. Irrigation water was salinised at the appropriate time, and soil salinity rose subsequently as salt was added with irrigation water but not leached away. This approach was used in one year to study salinisation strategies.

SCHEDULE OF EXPERIMENTS:

Summer 1989/90[1]	
Genotype comparison @ 6EC	- outdoor hydroponics
Genotype comparison @ 3EC	- field
Timing of salinisation	- field
Summer 1990/91	
Comparison of table and processing types	- outdoor hydroponics
Genotype comparisons	- field
Timing	- field
Winter 1991	
Physiological responses	- glasshouse hydroponics (2 experiments[2])
Summer 1991/92	
Genotype comparison	- field
Timing and Method of salinisation	- field
Pilot field studies	- Tatura

1. These experiments suffered the effects of flooding rain in March, 1990.

2. The first of these experiments failed when flowers did not set fruit in any treatment.

RESULTS AND DISCUSSION:

In this section, results are collated into themes and not presented chronologically.

1. **Genotypic differences in responses to salinity**:

i) *Processing versus table types (1990/91)*

In this experiment using hydroponic culture, cvv. H31 and Flora Dade, were compared at six solution conductivities in the range 1.5-8.0 mS/cm. Treatments commenced in early fruit set. The aim was to compare the shape of the relationship between yield and TSS as salt stress increased. Whilst this was not one of the earliest experiments conducted, it illustrates why genotype selection and salinisation strategy are key elements in developing the technology for irrigating processing tomatoes with saline water.

In both cultivars, TSS increased linearly with rising EC. Yield, however, decreased linearly in H31 as EC was raised above the control (1.5 mS/cm). In Flora Dade, yield decreased only when EC was raised above approximately 4.6 mS/cm and TSS had increased from 4.1 to 4.6 °brix (Fig.1).

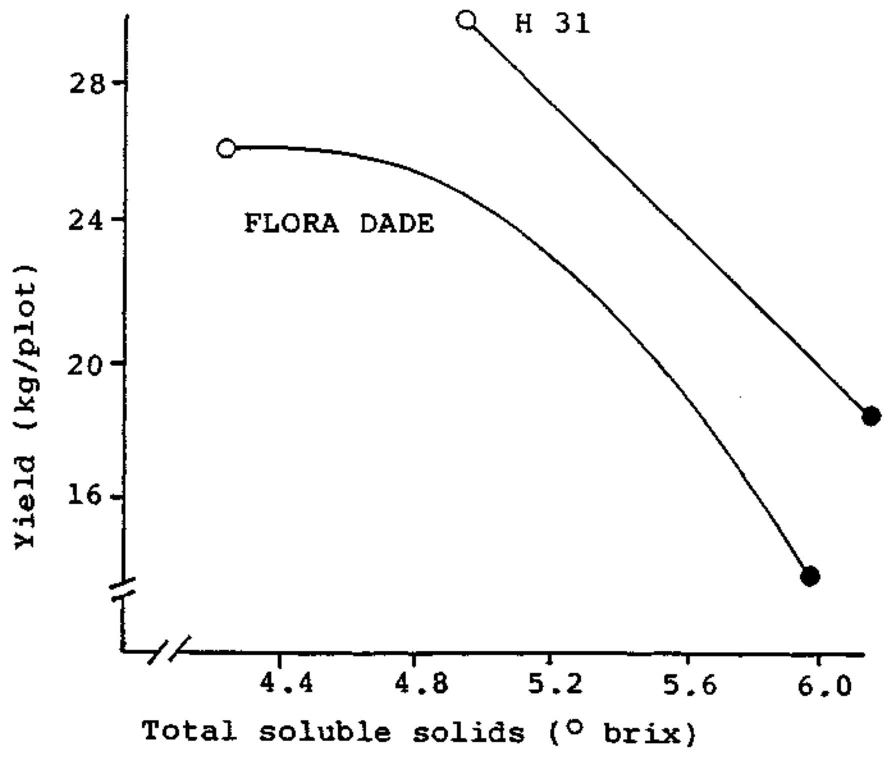

Fig. 1. The response of yield and total soluble solids of two tomato cultivars as nutrient solution conductivity was increased from 1.5 (O) to 12 (●) mS/cm.

This experiment confirmed that salt stress can significantly increase TSS in table tomatoes (≈ 0.5° brix) with no reduction in yield. It also confirmed results from 1989/90 which indicated that processing types may suffer a yield decrease when given the same salt regime as table types.

Measurements of leaf water potential and osmotic potential revealed similar responses to salt stress in the two cultivars, and this was supported by infrared thermometer measurements of air-leaf temperature differentials.

Measurements of leaf photosynthetic rate, though variable and inconclusive, suggested that photosynthetic rate remained (somewhat surprisingly) unaffected by salt stress, at least up to an EC of 4.5 mS/cm, in both cultivars. (This evidence is supported by later studies.)

The hypothesis arising from this work is that the contrasting yield response of the two types of tomatoes is most likely related to assimilate partitioning under mild salt stress. (Differences in yield response are unlikely to be related to effects on assimilation rate which may be related to salt injury *per se* or impaired plant water relations.)

Further, the difference in assimilate partitioning is likely to arise from differences in fruit set under slightly saline conditions. For example, indeterminate or semideterminate table types will continue to flower after salinisation commences, allowing plants to adjust flowering behaviour (numbers per unit of crop biomass) and/or fruit set (% of flowers resulting in fruit) in order to maintain reproductive sink size. Determinate processing types do not have this opportunity for reproductive adjustment. The spread of flowering in a genotype and the timing of salinisation would thus be factors in determining responses to salt.

Glasshouse experiments designed to test this hypothesis in 1991/92 gave inconclusive results, but the idea is currently being pursued by a student at UWS (Hawkesbury).

The hypothesis on assimilate partitioning, whilst unproven, led to proposals for salinisation strategies which are designed to increase TSS without reducing yield. These field experiments are reported later.

ii) *Comparison of processing genotypes*
This work comprised one experiment in hydroponics (1989/90) and three field experiments. A split plot design was used for logistical reasons, with main plots of salt treatment being split for genotype. The weakness in this design is that the physiological stage at which treatments commenced varied between cultivars.

All cultivars in all experiments responded to raised salinity by increasing TSS and reducing yield. The mean response of 8 cvv. in hydroponics is shown in Fig. 2.

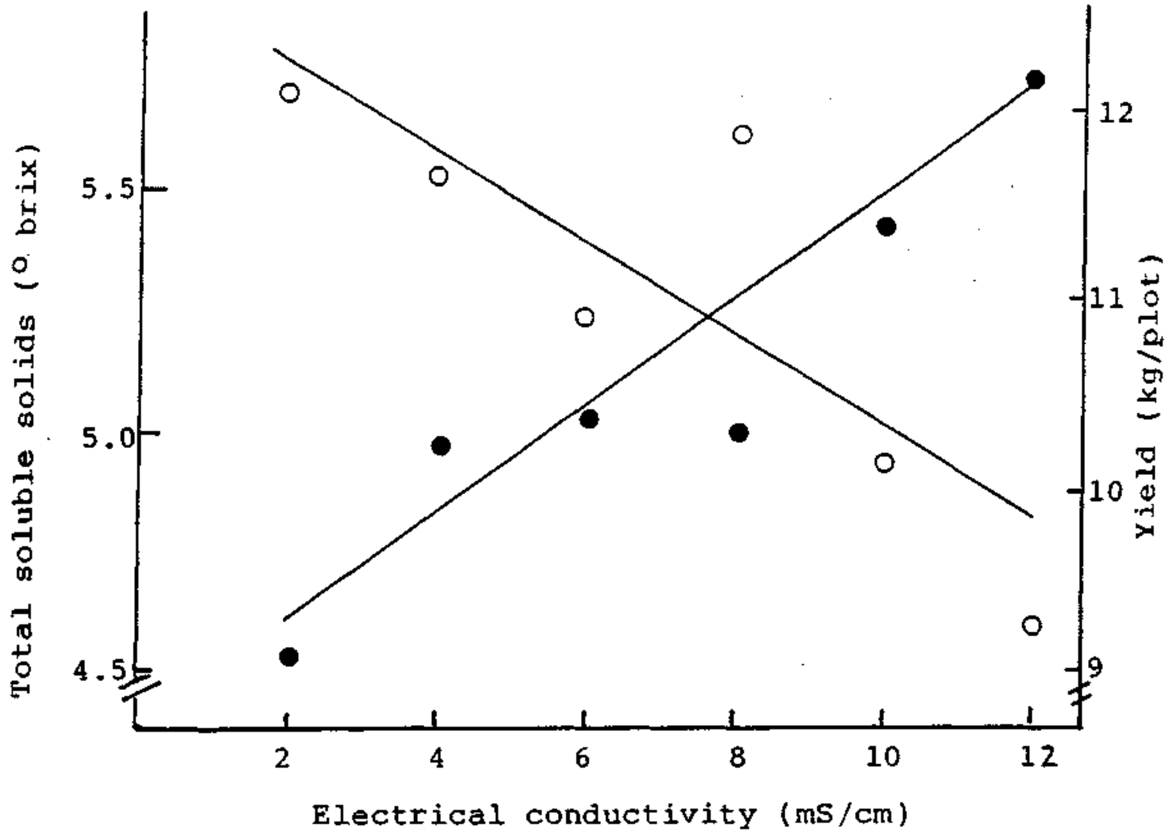

Fig. 2. The response of total soluble solids (●) and yield (O) to increasing electrical conductivity (salinity) of hydroponic nutrient solution. Mean of 8 cultivars.

Yield $y = 12.59 - 0.23x$ ($r^2 = 0.74$)

TSS $y = 4.40 + 0.102$ ($r^2 = 0.90$)

It is worth noting that the result in Fig. 2 was achieved with a harvest which followed several weeks of wet overcast weather, including flooding rains which removed all salt stress. This is encouraging, as it suggests that increases in TSS established before fruit ripening will not be lost if later rain relieves salt stress prior to harvest.

All cultivars gave the same general yield response to salt, and in none of the four experiments was the salt x cultivar interaction significant. Nevertheless, an overview of all four experiments suggests that interactions may occur but greater experimental precision is required to detect them statistically. From the present results it appears that cultivars which are inherently high in TSS still have the capacity to increase TSS when subjected to salt stress.

Results from two typical field experiments are shown in Tables 1 and 2.

Table 1. Responses to irrigation water salinity by six cultivars under field conditions - 1990/91

Irrigation water EC (mS/cm)	Cultivar					
	UC826	Alta	H31	6203	FM785	K7749
			Yield (kg/plot) - Ripe			
0.1	13.2	12.4	14.1	11.3	12.8	8.7
4.0	13.1	11.2	10.3	10.4	9.3	8.0
8.0	11.1	8.4	11.5	8.7	9.6	7.8
			Yield (kg/plot) - Total			
0.1	15.1	14.5	17.0	12.9	14.6	12.4
4.0	14.3	13.2	11.9	12.4	11.4	10.8
8.0	12.3	10.9	12.9	10.7	11.5	10.0
			TSS (%)			
0.1	4.25	4.65	4.45	4.93	5.01	4.80
4.0	4.68	5.33	5.28	5.35	5.60	5.53
8.0	5.00	6.00	5.50	5.80	6.00	5.85
			Solids yield (kg/plot) - ripe fruit			
0.1	0.56	0.58	0.63	0.56	0.64	0.42
4.0	0.61	0.60	0.54	0.56	0.52	0.44
8.0	0.56	0.50	0.63	0.50	0.56	0.46

In the data above, all main effects were significant ($P<0.05$) except for salinity in solids yield (n.s., $P>0.05$). No interactions were significant.

Table 2. Responses by six cultivars to raised electrical conductivity (EC) of irrigation water in 1992

Irrigation water (dS/cm)	Cultivar						
	Brigade	FM785	UC82B	Alta	6203	Shasta	Mean
				Yield (kg/plot)			
0.1	25.6	28.7	24.5	26.8	20.2	21.4	24.5
4.0	23.5	27.2	22.7	24.4	20.1	21.3	23.2
8.0	25.2	24.0	24.3	24.7	19.2	19.6	22.8
				TSS (%)			
0.1	4.9	4.7	4.8	5.0	4.7	4.9	4.83
4.0	5.1	5.1	4.9	5.3	5.0	5.5	5.15
8.0	5.4	5.4	5.3	5.7	5.5	5.5	5.47
				Solids yield (kg/plot)			
0.1	1.25	1.35	1.18	1.34	0.95	1.05	1.19
4.0	1.20	1.39	1.11	1.30	1.00	1.17	1.20
8.0	1.36	1.30	1.29	1.41	1.06	1.08	1.25

The results in 1992 again show that TSS increased in all varieties as the EC of irrigation water increased. Yield decreases occurred, but this time only in some varieties at some ECs.

Overall, solids yield (TSS x yield) increased with saline irrigation, with some varieties appearing to respond better than others. Brigade, UC82B, and 6203 gave good responses whilst Alta, FM785 and Shasta were relatively poor. Poor responses were associated with yield reductions.

2. **Timing and degree of salt stress**:
Work preceding this project had shown with table tomatoes that the right degree of salinsation would be necessary to optimise the trade-off between TSS and yield. This is confirmed by the data in Fig. 1, although the processing type (H31) revealed no optimal EC in that experiment. The data in Tables 1 and 2 reveal that there is potential for a satisfactory trade-off to be achieved with processing cultivars, although the degree of salinisation needed for best results may vary with cultivar.

Further evidence for the importance of timing of stress comes from overseas studies, and I have suggested already that cultivar differences may reflect a response to timing. Therefore a series of three field experiments studied different rates and timing of salinisation using the one cultivar, UC82B.

The methods section describes the two methods of salinisation used in these experiments. Briefly, Method 1 aimed at replacement of soil solution in the root zone over a short period of time (a few days) by leaching, whereas Method 2 progressively salinised the soil over many weeks by irrigating with saline water at a rate which matched crop water use. Fig. 3 shows soil solution EC values resulting from Method 2 salinisation in 1991/92. Late commencement of salinisation (Treatment 6) resulted in more rapid salisation because larger plants and warmer weather required more irrigation water.

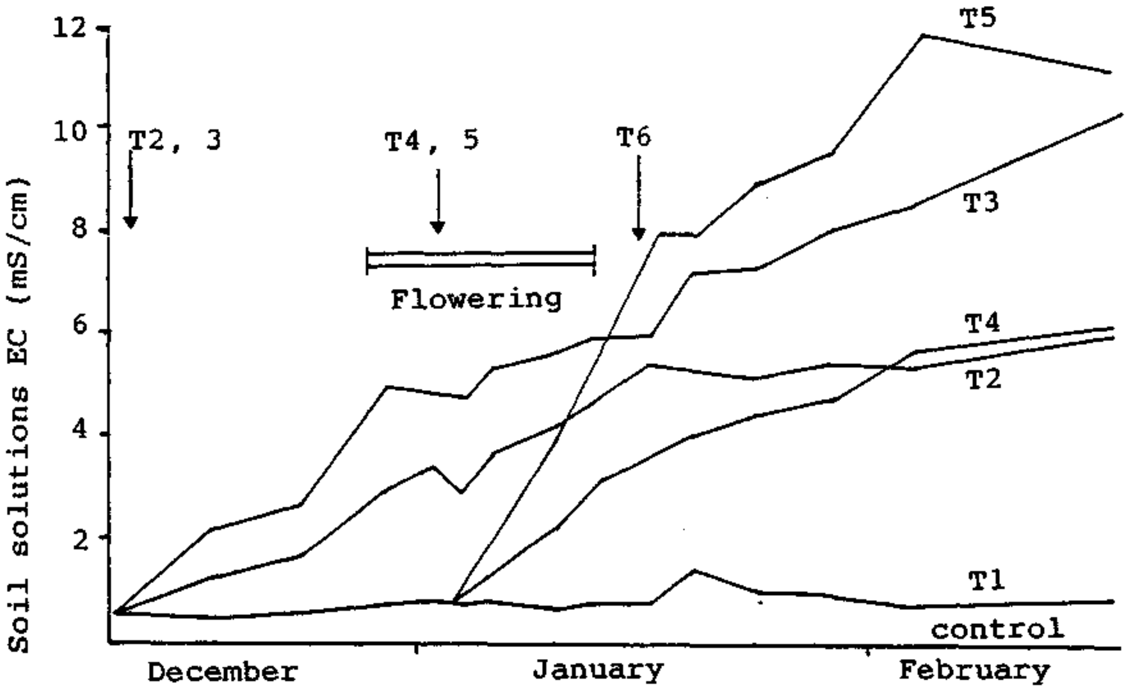

Fig. 3. Soil solution electrical conductivity (EC) at 30 cm depth in six salinity treatments in 1991/92. Treatments correspond to the six treatments shown for 1991/92 in Table 3, reading from left (T_1) to far right (T_6).

Soil solution EC in 1989/90 and 1990/91 was always close to the EC of irrigation water (8 mS/cm) because Method 1 salinisation was used and plots were irrigated to excess (made possible by the drainage beneath each plot). The exception in 1990/91 was the treatment initially salinised to 4 mS/cm then later to 8 mS/cm. This treatment approximated the mid flower, EC4 treatment in 1991/92.

The major results of these three large field experiments are drawn together into Table 3.

Table 3. YIELD (T/HA) AND TSS (°BRIX) RESPONSE TO TIMING OF SALINE IRRIGATION

All saline irrigation water in 1989/90 and 1990/91 was 8 mS/cm (Method 1 salinsation) except for "1990/91 mid flower", which was 4 mS/cm for 10 days from early flower then 8 mS/cm (Method 2 salinsation). The 1991/92 treatments are shown on the bottom line of the table, and are all Method 2.

Significant yield reductions shown **bold**

	STAGE WHEN SALINE IRRIGATION COMMENCED[1]					
	Control	PreFlower	Early Flower	Mid Flower[2]	Late Flower	Post Flower
1989/90 Yield (kg/ha)	65	-	**43**	75	62	56
TSS (° brix)	4.3	-	5.3	5.2	5.1	5.1
Solids yield	2.8		2.3	3.9	3.2	2.9
1990/91 Yield (kg/ha)	59	-	**45**	55	56	53
TSS (° brix)	4.3	-	5.3	5.3	4.7	4.6
Solids yield	2.5		2.4	2.9	2.63	2.4
1991/92 Yield (kg/ha)	55	49 **41**	-	54 **43**	-	57
TSS (° brix)	4.9	5.5 6.1	-	5.4 5.7	-	5.5
Solids yield	2.7	2.7 2.5	-	2.9 2.5	-	3.1
EC of soil at harvest (dS/m)	0.8	5.9 10.5	-	6.5[3] 11.5	-	6.0[3]
EC of irrigation water (dS/m)	0.2	2 4		4 8		4

1. Treatments at approx 10 day intervals
2. Mid flowering = 50% of plants with fruit 10-20 mm diameter
3. Estimated

The results in Table 3 show the following:

- All salt treatments increased TSS, and all but one of these increases was statistically significant.
- Irrigation with saline water had no effect on yield except:
  - i) when constant salt stress was suddenly imposed before mid flowering with irrigation water of 8 mS/cm in 1989/90 and 1990/91;
  - ii) when steadily rising stress commencing in mid flowering (irrigation water EC = 8 mS/cm) resulted in soil solution EC>11 mS/cm by harvest,
  - iii) when saline irrigation applied before flowering (4 mS/cm) resulted in soil solution about 5 mS/cm by mid flowering and 10 mS/cm by harvest.

- Solids yield increased by an average of 10% over all years and salinity treatments after excluding the treatments where yield was reduced. Over all treatments and years the increase was 3%.

These results from the field show clearly that, with an appropriate salinisation strategy, TSS in fruit can be increased with no yield loss, so solids yield per hectare can also be increased. The results also show that risks of reducing solids yield are low.

The best overall response to saline irrigation was when salinisation commenced in mid flowering (50% of fruit up to 20 mm diameter) and soil EC never exceeded about 6-8 mS/cm. This treatment increased solids yield by an average of 21% over the three years of study.

It should be noted that in 1989/90 rain during the last three weeks of the experiment leached salt from the soil profile but TSS still responded to the earlier salinisation.

3. Is the increase in fruit TSS due to organic solutes?
Ad hoc studies of fruit chemistry were made to check that increases in fruit TSS reflect an increase in sugars and acids, not direct salt uptake. Analyses of fruit hexose levels by Prof. John Patrick (U. Newcastle) showed that a 1° brix rise in TSS was associated with a 10% increase in hexose levels, sufficient to account for 50% of the rise in TSS. The remaining increase is accounted for by increased organic acids, not salt uptake, as discussed in Cornish (1992).

4. Validation in the Goulburn Valley (1991/92):
Mr. W. Ashcroft has provided the following notes.

An experiment was established at Tatura to test the effects of salt water application on processing tomato yield and quality under field conditions. The site was trickle irrigated on Goulburn loam. After plants reached the 2-4 true-leaf stage the following treatments were applied:

IRRIGATION:
- Control (channel water)
- 2.2 mS cm^{-1} applied from 2nd irrigation onwards to cut-off (2.2)
- 6.6 mS cm^{-1} applied from 2nd irrigation onwards to cut-off (6.6)
- normal irrigation to flowering, then 6.6 mS cm^{-1} applied from mid flowering to cut-off (6.6L)

CULTIVARS:
- UC82 (compact bush - industry standard, open-pollenated)
- Alta (medium vigorous commercial hybrid)

Plant growth, fruit yield and quality were measured, as well as the levels of salt in the soil. Soil solution measurements revealed that plant roots were subjected to levels of salt approximately equal to those in the irrigation water, which means that the root zone was sufficiently leached during normal irrigation operations, to prevent build-up of salt. Final harvest results, which give an indication of the commercial implications of the treatments, are shown in Table 4.

Table 4. Final harvest results from Tatura Field Experiment

Cultivar	Salt Treatment	YIELD (T/HA) Ripe	Green	Furrow	Total	Fruit Size (g)	Soluble Solids (%)	Solids Yield (T/HA)
UC82B	Control	63.9	14.5	2.7	81.1	52.1	4.83	3.08
	2.2	76.1	11.6	4.1	91.8	47.2	4.78	4.08
	6.6	59.0	12.6	5.9	77.5	41.6	5.10	3.01
	6.6L	77.0	12.5	4.0	93.5	49.0	4.77	3.67
ALTA	Control	78.0	11.7	4.3	94.0	72.4	5.23	4.08
	2.2	61.3	23.3	9.5	94.1	61.8	5.88	3.58
	6.6	72.6	12.0	4.3	88.9	65.5	5.75	4.15
	6.6L	70.6	12.1	6.7	89.4	76.9	5.65	3.99
LSD_{05}		20.0	7.2	6.3	26.7	7.8	0.4	1.30

The data show no detrimental effects on plant productivity from the application of moderately saline water to processing tomatoes. Although the differences were not significant, saline irrigation gave a small increase in solids yield (ripe yield x soluble solids) in UC82B. This appears to have been achieved through concentration of maturity, since there were lower green yields in UC82B under saline irrigation. Ripe yields were reduced by salt in Alta, but a significant increase in solids in salt treated plants meant that productivity was not affected. Salt treatment reduced fruit size in both cultivars, with the effect proportional to the rate of salt applied in UC82, but not in Alta.

These results reinforce those from Gosford, in that they show UC82 to be more responsive to salt, in terms of solids yield, than Alta. Furthermore, the figures suggest that the effects of higher levels of salt on tomato growth and productivity could be investigated.

Overall, these results show the potential for irrigating crops with slightly saline water. An increase in solids yield of 10% seems to be possible.

CONCLUSIONS AND IMPLICATIONS:
These experiments meet the goals of the project and demonstrate:

i) that TSS in fruit of processing genotypes responds to salt stress in the same way as in fresh market genotypes;

ii) all genotypes respond to salt stress, although the data give some evidence of variation in the magnitude of response;

iii) with care in the application strategy, increases in TSS can be achieved with little or no reduction in yield;

iv) that small yield reductions are offset by increases in TSS, resulting in maintenance of solids yield per hectare; and

v) salinisation which commences in mid flowering and results in soil solution EC not rising above approximately 6-8 mS/cm appears to be the safest and most effective.

Irrigation with saline water thus has commercial potential as a means of increasing solids yield. This potential, along with safety and risk considerations, is summarised in Fig. 4, where solids yield is related to soil solution EC.

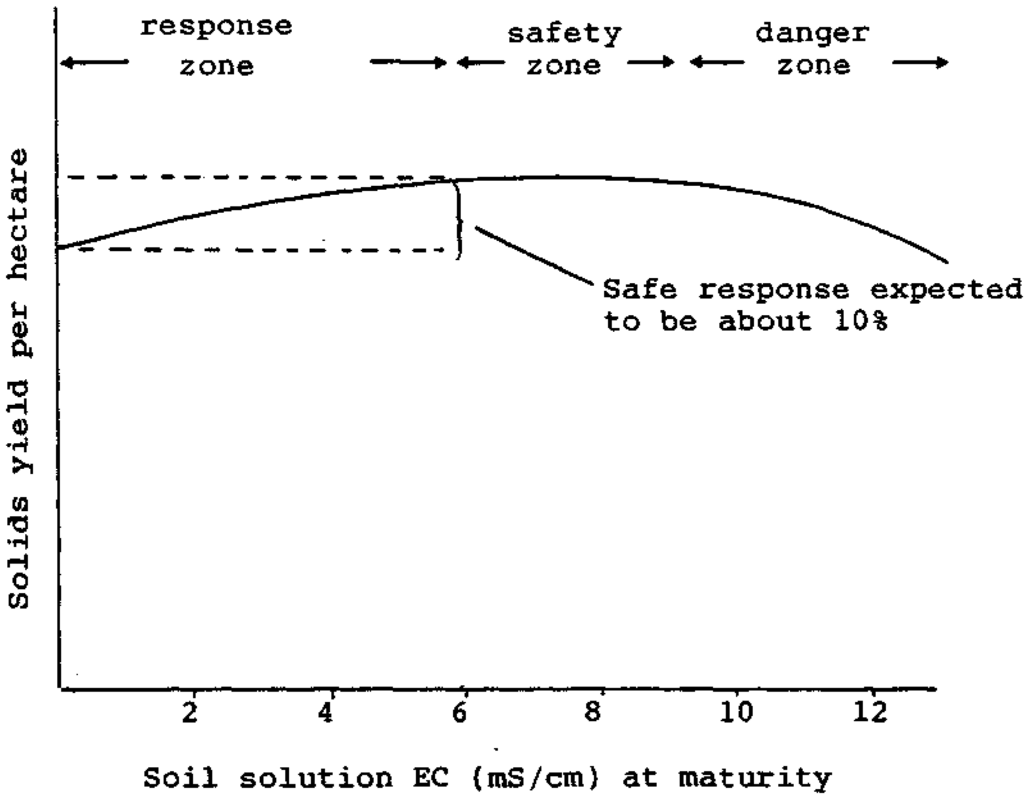

Fig. 4. Expected response to solids yield per hectare (dimensionless) to increases in soil solution electrical conductivity (EC).
Curve is indicative only, and is based on six field experiments at Gosford. A steady rise in EC after mid-flowering is assumed.

FUTURE WORK:

i) Crops:

- High priority. The relationship between solids yield and soil solution EC (Fig. 4) is based largely upon experience at Gosford, although it is consistent with the work at Tatura. Further work in the production areas is recommended to enable the equivalent of Fig. 4 to be produced. Such work should include cultivars which differ in their apparent response to salinity.

  Work with table tomatoes has shown that the optimal solution EC varies with climatic conditions (Cornish 1992). This would suggest that the optimal EC may be different at Tatura than Gosford, and that hot, dry seasons at Tatura would require a lower solution EC than cool, moist seasons. However, Fig. 4 (if confirmed for Tatura) suggests that an EC mid way along the plateau (say 8 mS/cm) would give good responses in mild years and still be safe in wet years.

- Lower priority. Where yield losses occurred under high EC, this was always associated with an increase in blossom-end rot. Further work on Ca nutrition may therefore be warranted. Other lower-priority work on crops would include interactions with N and P nutrition, and a check on the response of crops in salinised soil to under-irrigation (a potential hazard in commercial crops). A diagnostic tool is also needed for growers, to ensure soil solution EC does not rise to dangerous levels. At present, suction samplers and EC measurements with a simple conductivity meter appears to be the best way to go, although plant stress indicators may also be feasible.

ii) Soils:

Any proposal to irrigate crops with saline water must consider the response of soils to that irrigation. It is recommended, therefore, that commercial application of saline irrigation water be considered congruently with research on the response of soils. This research is already underway in pastures.

COMMUNICATIONS

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