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THE EFFECTS OF HIGH CONDUCTIVITY LIQUID FEEDS ON THE YIELD AND QUALITY OF OUTDOOR GROWN TOMATOES

A Thesis Presented in Partial Fulfilment of the Requirements
for the Degree of Master of Horticultural Science in
Vegetable Production at Massey University
Palmerston North, New Zealand

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ABSTRACT

Studies were conducted to evaluate the effects of high conductivity liquid feeds applied using drip irrigation on the yield and quality of outdoor grown tomatoes. Seed of the tomato cv. *Extase* were propagated in cell trays. During propagation the seedlings were fed using a stock solution containing 100 ppm nitrogen, 34 ppm phosphorous and 100 ppm potassium. The transplants were planted out on 3 December 1991 in the Karapoti Sandy Loam soil at the Plant Growth Unit, Massey University. The spacing used was 150 cm between the rows and 60 cm 2 in the row. A base maintenance dressing of Nitrophoska (12-10-10) fertilizer was applied at a rate of 500 kg per hectare banded 20 cm on either side of the row prior to planting.

There were 3 conductivity treatments of 2, 4, and 6 mS cm^{-1} and a control treatment. A randomized complete block design was used with 4 blocks and 12 plants per plot. The 3 conductivity treatments were based on a standard greenhouse liquid feed, while the control plant received water only. Irrigation requirements were calculated based on a crop factor, area per plant and potential evapotranspiration. Conductivity treatments commenced at the stage were 50% of the plants had commenced flowering on the first truss. Conductivity treatments were applied every 2 days for 2 hours regardless of rain, while control plants were irrigated with tap water when soil moisture deficits exceeded 28 mm day^{-1} except when rainfall immediately followed the scheduled irrigation.

Plants were trained to 2 stems. The second stem was produced from the leaf axil immediately below the first inflorescence. The Otaki system of training and supporting tomato plants was used with the first support attached 25 days after planting and thereafter every 30 cm. Plants were delateraled regularly and stopped by removing the terminal buds at 2 metres high.

Leaf analysis was carried out on 2 occasions, 30 and 55 days after planting, while the conductivity of the soil solution was determined at final harvest. Yield data was collected for each truss on a per stem basis per plant. Fruit were weighed individually and also size graded to the accepted commercial standard. From these data the number and weight of marketable and reject fruits were determined. Fruit samples were taken for 6 consecutive weekly harvests for compositional analysis. Firmness, total solids, titratable acidity and total soluble solids were measured from sample fruits from each treatment.

Increasing the conductivity of the liquid feed increased the concentration of nitrogen and potassium in the leaves 30 days after planting, while phosphorous and magnesium were not affected by the treatments. Calcium fell with each increase in conductivity. At the reproductive stage (55 days after planting) the nitrogen, phosphorous and potassium content fell with increasing conductivity over the range of control to 4 mS cm^{-1}. Calcium and magnesium content also fell with increasing conductivity of the liquid feed. The conductivity of the soil solution increased as the conductivity of the liquid feed increased. As the distance from the dripper increased the conductivity of soil solution decreased.

Tomato plants in this study supported an average of 13 trusses. There were 18 harvests where fruits were harvested at a commercial acceptable stage of maturity and a 19th harvest was used to remove all the remaining fruit on the plant . The main stem carried approximately 65% of the fruit load. Conductivity treatments had no effect on the number and weight of fruit of individual trusses on the main stem except for the 4 mS cm^{-1} treatment which had a higher number and yield of fruit in the third truss. No explanation can be offered for this effect. There were no differences between treatments in the number or yield of fruit per truss on the lateral stem.

Neither the number or yield of marketable fruit or the total number or total yield of fruit at final harvest were affected by the conductivity treatments. There was however a trend for yield to decrease with the 6 mS cm^{-1} treatment. It is possible that if the experiment had been continued for a longer period a treatment effect on the number and yield of fruit may have been obtained. It was suggested that the heavy rain experienced during the experiment may have delayed the occurrence of a yield reduction. Although there was no significant effect of conductivity on fruit size, the number of fruit in the two largest size grades tended to be highest for the control plants, while the 6 mS cm^{-1} treatment had the smallest number of fruit in these size grades. This is further evidence that the conductivity treatments tended to have an effect on fruit size and thus yield.

The main cause for fruits to be rejected was due to fruit cracking, which usually occurred when harvesting preceded heavy rainfall.

The occurrence of blossom end rot was low since both rainfall and the regular application of liquid feeds did not place the plants under a fluctuating moisture stress. Overall there were very few rejects.

The conductivity treatments increased titratable acidity above that of control plants, but there were no difference between the conductivity treatments. Over time titratable acidity of the fruit declined and this may have been associated with either a seasonal effect or the position of the fruit on the stem. Total solids was increased as the concentration of the liquid feeds increased. The percentage of total solids allocated to structural material fell as the concentration of the liquid feed increased. This suggests that the increase in the total solids was due to an increase in the soluble solid component. There was no effect of conductivity on fruit firmness, however firmness fell from an initial value at harvest 1. Total soluble solids of the fruit increased with each increase in conductivity. Over time the trend was for soluble solids to fall slightly up to harvest 5 with a marked decline occurring at harvest 6.

As improvements in fruit flavour are associated with increases in titratable acidity, total solids and total soluble solids the conductivity treatments used in this experiment were successful in improving this aspect of fruit quality. This was achieved without any decrease in yield. As suggested however, a trade off between quality and yield may have occurred if the experiment had been continued for a longer period of time.

This research suggests that the use of trickle irrigation to supply high conductivity liquid feeds to field grown tomatoes has the potential to significantly improve fruit flavour.

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GENERAL INTRODUCTION

The tomato is a highly valued outdoor crop in New Zealand. It is grown commercially whenever environmental conditions permit an economic yield to be obtained. Consumers continue to use large amounts of this product, but increasingly there has been publicity which suggest that tomatoes are not what they used to be. This is so because plant breeders and producers in their attempt to produce high yields have, according to a widely held view, sacrificed fruit quality.

Up until recently the important quality attributes of the tomato were perceived to include size, shape, colour and firmness of the fruit. At the present time however consumers are increasingly suggesting that fruit flavour should be added to this list. It is well established that the quality of tomato fruit can vary in response to both genetic and environmental factors. It is likely that tomato breeding programs for both greenhouse and outdoor tomatoes will now start to consider improvements in fruit flavour as an important goal. Research has established that there is a close relationship between acid and sugar levels in tomato fruit and fruit flavour. Recent developments with greenhouse tomatoes has shown that increases in titratable acidity and total soluble solids can be achieved by the use of high conductivity liquid feeds. These improvements in quality have been associated with some loss of yield.

Drip irrigation refers to the application of irrigation water and fertilizer nutrients through small emitters placed on or in the soil near the plants. One of the advantages of drip irrigation is its ability to conserve water and fertilizer compared with other irrigation and fertilizer systems. With drip irrigation water is not applied to plant foliage maintaining drier plants and reducing susceptibility to disease outbreak with an associated reduction in the need for fungicides. Drip irrigation has been widely used with field vegetable crops in the USA.

The objective of the research discussed in this thesis was to use drip irrigation to examine the potential of using high conductivity liquid feeds to improve the flavour of field grown fenced tomatoes. Of particular interest was the likely trade off between fruit quality and yield.