

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

FLOWER AND FRUIT DEVELOPMENT IN PROCESSING TOMATOES

A THESIS PRESENTED IN PARTIAL  
FULFILMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF MASTER OF HORTICULTURAL SCIENCE  
IN VEGETABLE PRODUCTION AT MASSEY UNIVERSITY

ANTHONY PETER JULIAN

1990

ABSTRACT

Processing tomato crops are mechanically harvested from a single destructive harvest. The timing of this harvest to coincide with the maximum yield of factory grade fruit is of considerable importance to the efficiency of the field operation. There is a lack of information regarding where the factory grade fruit is produced on the plant and for how long the yield of factory grade fruit is maintained at its maximum level in the field.

Two experiments were carried out in the Manawatu using the processing cultivars Castlehye 1204 Improved and UC 82B. The first experiment determined the time of flowering of all the flowers on the plant, the trusses in which these flowers were to be found and the position of these trusses on the plant. 132 days after planting all the plants were harvested and the number and position on the plant of the flowers which set fruit was determined. A normal distribution was found to satisfactorily describe the relationship between the number of flowers reaching anthesis and time. Plants on average carried up to 37 trusses. 65% of the yield was carried on the first 10 trusses to flower with 95% of the yield carried on the first 20 trusses to flower. The efficiency of trusses in producing fruit varied from 66% with the earlier flowering trusses down to negligible levels. Plants had up to 8 main order laterals and together with their attached sub laterals each carried from 4-5 trusses. The efficiency of flowering decreased with the position of the truss up the lateral. It was suggested that the competition

between trusses for assimilates is far more important within laterals than between laterals. These results have implications for both crop management and plant breeding programmes.

In the second experiment 9 successional destructive harvests were carried out commencing at the first sign of coloured fruit. Ethryl was not applied to the crop. The yield of red and factory grade fruit was found to peak sharply over time. The normal distribution curve was found to satisfactorily describe the relationship between time and the yield of both red and factory grade fruit and fruit numbers of these grades of fruit. Harvesting one week earlier or one week later than the optimum harvest date resulted in a loss of factory grade fruit of from 10-15 tonnes per hectare. The major cause for this rapid fall in yield from the optimum was due to an increase in the yield of red rotten fruit. In fact over half of the total number of fruit had rotted by 136 days after planting. This included a significant number of green fruit. The magnitude of this loss was only apparent because successional harvests were carried out. The total yield of fruit (all grades) was maintained over a considerable period as the loss in fruit numbers was balanced by the increase in mean fruit weight of the crop. The mean fruit weight of fruit did not increase once they had coloured. The percent soluble solids of red fruit decreased the week following any significant amount of rainfall.

In the light of this research the effect of ethryl on the maturity characteristics of processing tomato crops needs to be re-examined by the use of successional harvests. Reliable techniques also need to be developed to predict the time of optimum harvest as these results suggest that it is much shorter than is commonly thought. The importance of fruit rots in reducing yields and thus effecting the length of the optimum

harvest period is also apparent and is another area of research which requires further study.

In the first experiment, the Normal Distribution Curve was found to describe the frequency of flower anthesis versus time relationship in two processing tomato cultivars; Castlehye 1204 Improved and UC 82B. Early fruit setting flowers acted as a strong sink as 90% of the final yield was carried on the first 18 trusses. Yield contributing trusses followed a pattern of increasing distance from the root system the later they flowered. Competition for photosynthate was mainly within laterals but also there was some between lateral competition. Flower trusses exhibited decreasing efficiencies in producing red fruit the later first flower anthesis occurred on the flower truss.

In the second experiment, the yield of Factory Grade tomato fruit from the same two processing tomato cultivars peaked sharply over time. Harvesting one week earlier or later than the optimum harvest date resulted in a Factory Grade yield loss of up to 10-15 t ha<sup>-1</sup> for both cultivars. The Normal Distribution Curve was found to describe the relationship between Factory Grade fruit weight and number over time for both cultivars. Both red and coloured fruit weight were also found to follow the Normal Distribution. Over half of the total number of fruit rotted by 136 days after planting. Percentage Soluble Solids of red fruit decreased as rainfall increased in the week preceding harvest, with the converse also shown to apply.

### ACKNOWLEDGEMENTS

I am extremely grateful to Dr. K.J. Fisher and Dr. M.A. Nichols for their guidance and supervision during the experiments and preparation of this thesis.

I sincerely appreciate the help given to me by Mr. B. Mckay and Mr. S. Davis in designing and analysing the experiment.

I am indebted to Massey University for allowing me to carry out the experiments while in their employment.

Finally I would like to thank my wife Janet for her help and encouragement during the experiment and thesis preparation.

TABLE OF CONTENTS

	<u>PAGE</u>
ABSTRACT .....	II
ACKNOWLEDGEMENTS .....	V
TABLE OF CONTENTS .....	VI
LIST OF TABLES .....	X
LIST OF FIGURES .....	XI
LIST OF PLATES .....	XIII
LIST OF APPENDICES .....	XIV
INTRODUCTION .....	1
APPENDICES .....	97
BIBLIOGRAPHY .....	113

	<u>PAGE</u>
CHAPTER ONE: LITERATURE REVIEW .....	2
1.1 VEGETATIVE DEVELOPMENT OF THE PLANT ...	2
1.1.1 DEVELOPMENT STAGES .....	2
1.1.1.1 FACTORS AFFECTING GERMINATION .....	2
1.1.1.2 VEGETATIVE DEVELOPMENT .....	4
1.1.2 GROWTH FORMS .....	5
1.1.2.1 INDETERMINATE .....	5
1.1.2.2 DETERMINATE .....	6
1.1.2.3 DWARF .....	6
1.1.2.4 MINIATURE .....	7
1.1.2.5 JOINTLESS .....	7
1.1.3 ATTRIBUTES FOR PROCESSING TOMATO VARIETIES .....	7
1.2 FLOWERING .....	8
1.2.1 FLOWER MORPHOLOGY .....	9
1.2.2 FLOWER DEVELOPMENT .....	9
1.2.2.1 FLOWER INITIATION .....	9
1.2.2.2 DEVELOPMENT .....	11

1.2.3	FLOWERING PATTERN AND THE EFFECTS OF THE SOURCE SINK RELATIONSHIPS .....	12
1.2.4	THE INFLUENCE OF CULTURAL FACTORS ON FLOWERING, FRUIT SET AND YIELD .....	13
1.2.4.1	PLANT SPACING .....	13
1.2.4.2	IRRIGATION .....	14
1.2.4.3	FERTILIZER .....	15
1.2.4.4	PLANT GROWTH REGULATORS .....	16
1.3	FRUIT DEVELOPMENT .....	17
1.3.1	FRUIT SETTING .....	17
1.3.1.1	POLLINATION .....	18
1.3.1.2	FERTILIZATION .....	18
1.3.1.3	PARTHENOCARPIC FRUIT FORMATION .....	18
1.3.2	FRUIT DEVELOPMENT .....	19
1.3.2.1	GROWTH RATE .....	19
1.3.2.2	SOURCE/SINK RELATIONSHIPS .....	20
1.3.2.3	CHEMICAL CHANGES .....	22
1.3.3	FRUIT RIPENING .....	23
1.3.3.1	PHYSIOLOGY .....	23
1.3.3.2	ETHYLENE PRODUCTION AND APPLICATION ..	23
1.3.4	FRUIT QUALITY FOR PROCESSING .....	25
1.3.4.1	GRADES .....	26
1.3.4.2	FIRMNESS .....	27
1.3.4.3	SOLUBLE SOLIDS .....	27
1.3.4.4	VINE STORAGE .....	29
1.4	THE PROCESSING TOMATO INDUSTRY IN NEW ZEALAND. ....	29
1.4.1	AREAS GROWN .....	29
1.4.2	CULTIVARS .....	29
1.4.3	ESTABLISHMENT METHODS .....	29
1.4.4	PLANT SPACING	30
1.4.5	POST ESTABLISHMENT CARE .....	30
1.4.5.1	FERTILIZER .....	30
1.4.5.2	WEED CONTROL .....	30
1.4.5.3	IRRIGATION .....	31
1.4.5.4	PEST AND DISEASE CONTROL .....	31
1.4.5.5	CHLORETHEPHON APPLICATION .....	31
1.4.6	HARVESTING .....	32



1.4.7	YIELDS .....	32
1.4.8	MARKETING .....	32
CHAPTER TWO: EXPERIMENT ONE .....		33
2.1	INTRODUCTION .....	33
2.2	MATERIALS AND METHODS .....	33
2.2.1.1	PRODUCTION OF CELL TRANSPLANTS .....	33
2.2.2	PREPARATION OF THE FIELD AREA .....	34
2.2.3	TRANSPLANTING .....	34
2.2.4	MAINTENANCE OF THE EXPERIMENT AFTER ESTABLISHMENT .....	37
2.2.5	EXPERIMENTAL DESIGN .....	37
2.2.6	RECORDING AND ANALYSES OF DATA .....	37
2.3	RESULTS .....	39
2.3.1	FLOWERING PATTERN FOR ALL FLOWERS ...	39
2.3.2	FLOWERING PATTERN FOR FLOWERS WHICH PRODUCE FRUIT .....	39
2.3.3	TRUSS POSITION ON THE PLANT .....	40
2.3.4	RELATIONSHIP BETWEEN TRUSS POSITION AND FRUIT DEVELOPMENT .....	42
2.4	DISCUSSION .....	42
2.4.2	GENERAL DISCUSSION .....	42
2.4.3	COMMERCIAL IMPLICATIONS .....	44
2.4.3	RESEARCH IMPLICATIONS .....	44
CHAPTER THREE: EXPERIMENT TWO .....		45
3.1	INTRODUCTION .....	45
3.2	MATERIALS AND METHODS .....	45
3.2.1	INTRODUCTION .....	45
3.2.2	EXPERIMENTAL DESIGN .....	47
3.2.3	DATA COLLECTION .....	47
3.2.4	ANALYSIS OF DATA .....	50
3.3	RESULTS AND DISCUSSION .....	52
3.3.1	PATTERN OF FRUIT MATURITY .....	52
3.3.1.1	GREEN FRUIT .....	52

3.3.1.2	COLOURED, RED AND FACTORY GRADE FRUIT	53
3.3.1.3	ROTTEN FRUIT .....	53
3.3.1.4	SMALL FRUIT .....	53
3.3.1.5	TOTAL FRUIT PRODUCTION .....	54
3.3.2	MATURITY CHARACTERISTICS OF PROCESSING GRADES OF FRUIT	54
3.3.3	SOLUBLE SOLIDS .....	55
3.3.4	COMMERCIAL IMPLICATIONS .....	61
3.3.5	RESEARCH IMPLICATIONS .....	61

LIST OF TABLES

	<u>PAGE</u>
TABLE I	CHANGES IN COMPOSITION DURING RIPENING (GRIERSON AND KADER, 1986) ..23
TABLE II	RIPENESS CLASSES OF TOMATOES .....26
TABLE III	MATURITY CLASSES OF GREEN TOMATOES ...26
TABLE IV	NUTRIENT UPTAKE LEVELS .....30
TABLE V	SIZE OF TRANSPLANTS AT PLANTING .....35
TABLE VI	TOMATO FRUIT GRADES .....47
TABLE VII	PREDICTED MAXIMUM WEIGHT, NUMBERS OF RED FRUIT AND HARVEST DATE FOR RED AND FACTORY GRADES OF FRUIT. ....55

## LIST OF FIGURES

	<u>PAGE</u>
FIGURE I.	NUMBER OF FLOWER OPENINGS PER DAY PER PLANT (COMBINED DATA. cvs. CASTLEHY 1204 AND UC 82B). . . . .64
FIGURE II.	NUMBER OF FLOWER OPENINGS PER DAY PER PLANT WHICH PRODUCE FRUIT (COMBINED DATA cvs. CASTLEHY 1204 AND UC 82B) - GRAPH 1. . . . .65
FIGURE III.	NUMBER OF FLOWER OPENINGS PER DAY PER PLANT WHICH PRODUCE FRUIT (COMBINE DATA cvs. CASTLEHY 1204 AND UC 82B) - GRAPH 2. . . . .66
FIGURE IV.	EFFICIENCY OF TRUSSES IN PRODUCING RED FRUIT. . . . .67
FIGURE V.	EFFICIENCY OF TRUSSES IN PRODUCING FACTORY GRADE (RED AND COL.) FRUIT. . .68
FIGURE VI.	EFFICIENCY OF TRUSSES IN PRODUCING RED, COLOURED AND GREEN FRUIT. . . . .69
FIGURE VII.	CUMULATIVE PERCENTAGE OF THE NUMBER OF RED FRUIT PRODUCED ON EACH TRUSS. .70
FIGURE VIII.	CUMULATIVE PERCENTAGE OF THE NUMBER OF FACTORY GRADE (RED AND COLOURED) FRUIT PRODUCED ON EACH TRUSS. . . . .71
FIGURE IX.	CUMULATIVE PERCENTAGE OF THE NUMBER OF RED, COLOURED AND GREEN FRUIT PRODUCED ON EACH TRUSS. . . . .72
FIGURE X.	WEIGHT OF FRUIT PER HECTARE FOR cv. CASTLEHY 1204 (GRAPH 1). . . . .73
FIGURE XI.	WEIGHT OF FRUIT PER HECTARE FOR cv. CASTLEHY 1204 (GRAPH 2). . . . .74

FIGURE XII.	WEIGHT OF FRUIT PER HECTARE FOR cv. UC 82B (GRAPH 1). . . . .	75
FIGURE XIII.	WEIGHT OF FRUIT PER HECTARE FOR cv. UC 82B (GRAPH 2). . . . .	76
FIGURE XIV.	WEIGHT OF RED FRUIT AND GENERATED NORMAL CURVE FOR cv. CASTLEHY 1204. . .	77
FIGURE XV.	WEIGHT OF FACTORY GRADE (RED AND COLOURED) FRUIT AND GENERATED NORMAL CURVE FOR cv. CASTLEHY 1204. . .	78
FIGURE XVI.	WEIGHT OF RED FRUIT AND GENERATED NORMAL CURVE FOR cv. UC 82B. . . . .	79
FIGURE XVII.	WEIGHT OF FACTORY GRADE (RED AND COLOURED) FRUIT AND GENERATED NORMAL CURVE FOR cv. UC 82B. . . . .	80
FIGURE XVIII.	NUMBERS OF FRUIT PER HECTARE FOR cv. CASTLEHY 1204. . . . .	81
FIGURE XIX.	NUMBERS OF FRUIT PER HECTARE FOR cv. UC 82B. . . . .	82
FIGURE XX.	FRUIT WEIGHT FOR cv. CASTLEHY 1204. . .	83
FIGURE XXI.	FRUIT WEIGHT FOR cv. UC 82B. . . . .	84
FIGURE XXII.	WEEKLY RAINFALL AND COMBINED SOLUBLE SOLID MEANS FOR cvs. CASTLEHY 1204 AND UC 82B. . . . .	85
FIGURE XXIII.	DIAGRAMMATIC REPRESENTATION OF A TYPICAL PROCESS TOMATO PLANT. . . . .	86

-----

LIST OF PLATES

PLATE I.	EXPERIMENTAL AREA AFTER PLANTING .....	36
PLATE II.	PLANTS ONE DAY AFTER PLANTING	.36
PLATE III.	TOWARDS THE END OF FLOWERING. ....	38
PLATE IV.	A CLOSEUP OF THE FLOWER RECORDING TAGS. ....	38
PLATE V.	UC 82B PLANT WITH THE FRUIT ATTACHED .....	41
PLATE VI.	UC 82B PLANT AFTER THE FRUIT WAS REMOVED. ....	41
PLATE VII.	FRUITING PATTERN EXPERIMENT EARLY FEBRUARY, 1987. ....	46
PLATE VIII.	FRUITING PATTERN EXPERIMENT AFTER THE FIRST HARVEST. ....	46
PLATE IX.	TRANSPORT OF FRUIT FROM THE FIELD. ...	49
PLATE X.	GRADING TABLE .....	49
PLATE XI.	FRUIT FROM THE FIRST HARVEST	..51
PLATE XII.	FRUIT FROM THE LAST HARVEST	..51
PLATE XIII.	FIRST HARVEST. ....	56
PLATE XIV.	SECOND HARVEST. ....	56
PLATE XV.	THIRD HARVEST. ....	57
PLATE XVI.	FOURTH HARVEST. ....	57
PLATE XVII.	FIFTH HARVEST. ....	58
PLATE XVIII.	SIXTH HARVEST. ....	58
PLATE XIX.	SEVENTH HARVEST. ....	59
PLATE XX.	EIGHTH HARVEST .....	59
PLATE XI.	NINTH HARVEST .....	60

## LIST OF APPENDICES

	<u>PAGE</u>
APPENDIX I.	CELL TRANSPLANT MEDIA .....87
APPENDIX II.	SPRAY PROGRAMME .....88
APPENDIX III.	SEEDLING LIQUID FEED .....89
APPENDIX IV.	EXPERIMENTAL AREA SOIL TEST VALUES ..90
APPENDIX V.	FREQUENCY OF FLOWER OPENING - COMBINED DATA FOR BOTH CULTIVARS ..91
APPENDIX VI.	FREQUENCY OF FLOWER OPENINGS WHICH PRODUCE FRUIT - COMBINED DATA FOR BOTH CULTIVARS ....92
APPENDIX VII.	NORMAL DISTRIBUTION CURVE STATISTICS (EXPERIMENT ONE) .....93
APPENDIX VIII.	EFFICIENCY OF TRUSSES IN PRODUCING FRUIT .....94
APPENDIX IX.	CUMULATIVE PERCENTAGE OF THE NUMBERS FRUIT PER TRUSS .....95
APPENDIX X.	FRUIT WEIGHT DATA .....97
APPENDIX XI.	FRUIT NUMBER DATA .....103
APPENDIX XII.	INDIVIDUAL FRUIT WEIGHT DATA (MEANS OF BLOCKS) .....109
APPENDIX XIII.	NORMAL DISTRIBUTION CURVE STATISTICS (EXPERIMENT TWO) .....110
APPENDIX XIV	RED FRUIT SOLUBLE SOLIDS .....111
APPENDIX XV	RAINFALL IN SEVEN DAY INTERVALS OVER THE HARVEST PERIOD .....112

## INTRODUCTION

An important criteria for the successful harvesting of processing tomatoes, is that a high proportion of the fruit harvested is at the correct stage of maturity for processing. In New Zealand, processing tomatoes are generally harvested when a sample drawn from the crop indicates that optimum maturity has been achieved.

The objective of this study was to demonstrate how the time of harvest for two common cultivars of processing tomatoes used in New Zealand, is very critical and harvesting outside the optimum time can result in a large loss of potential yield. It was also decided to study the flowering pattern of the same two tomato cultivars to find which flower trusses were contributing to the yield of processing grade fruit.