Processing Tomato Production in the Burdekin

Opportunities & Risks for Growers

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June 2012

Queensland Government

Australian Government
Department of Agriculture, Fisheries and Forestry

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Acknowledgements

This project was conducted with funding from the Department of Agriculture, Fisheries and Forestry (DAFF, Canberra). We would like to thank SPC Ardmona for their support when the project was being developed and for providing access to their trial data. We also thank Ross Wright (previously the senior extension officer at the DAFF Bowen Research Station) and Jamie Jurgens private grower (VJs Tomatoes) in Euri Creek.

Executive Summary

The research undertaken here was in response to a decision by a major food producer in about 2009 to consider establishing processing tomato production in northern Australia. This was in response to a lack of water availability in the Goulburn Valley region following the extensive drought that continued until 2011. The high price of water and the uncertainty that went with it was important in making the decision to look at sites within Queensland. This presented an opportunity to develop a tomato production model for the varieties used in the processing industry and to use this as a case study along with rice and cotton production.

Following some unsuccessful early trials and difficulties associated with the Global Financial Crisis, large scale studies by the food producer were abandoned. This report uses the data that was collected prior to this decision and contrasts the use of crop modelling with simpler climatic analyses that can be undertaken to investigate the impact of climate change on production systems.

Crop modelling can make a significant contribution to our understanding of the impacts of climate variability and climate change because it harnesses the detailed understanding of physiology of the crop in a way that statistical or other analytical approaches cannot do. There is a high overhead, but given that trials are being conducted for a wide range of crops for a variety of purposes, breeding, fertiliser trials etc., it would appear to be profitable to link researchers with modelling expertise with those undertaking field trials. There are few more cost-effective approaches than modelling that can provide a pathway to understanding future climates and their impact on food production.

Introduction

The initial focus of this study was on processing tomato production in the Burdekin and was reliant on the involvement of SPC Ardmona in the development of a processing plant and continued trials in the Burdekin. The decision by the parent company (Coca-Cola Amatil) to halt this work was not unforseen and due, in part, to the impact of the global financial crisis. This was a financial decision and does not necessarily indicate that production in north Queensland was not viable from a bio-physical perspective.

This report examines the potential to establish a processing tomato industry in the Burdekin based on successful production of fresh tomatoes in the area around Bowen. It draws heavily on the report by Deuter (2011) and Mills (2010) and uses a field trial conducted in collaboration with SPC Ardmona in 2010 to parameterise an existing tomato crop growth model. As only one field trial was available with data suitable for this part of the study we have limited the application of the model to the Burdekin.

This research demonstrates the importance of extending the critical thresholds approach of Deuter (2011) because of the interaction of elevated CO2 and higher temperatures under climate change.

Background to the Australian processing tomato industry

Up until 2010, growers of processing tomatoes could provide produce to three processors, Cedenco, Heinz and SPC Ardmona. In 2012, Heinz ceased operations in Australia and moved production to New Zealand and currently SPC Ardmona buys product from Cedenco rather than directly from the growers (ACCC 2012). Cedenco supplies about 80% of the processed tomato products used in Australia and since 2006 these are sourced through its own subsidiary, SS Farms Pty Ltd, and a small number of contracted growers (12 growers have consistently provided tomatoes in recent years). The production from independent growers has declined from 94% in 2006 to 55% in 2010. The growers contracted to Cedenco provide produce at a volume and timing stipulated by Cedenco to meet its processing needs. Additionally, harvesting and transport of produce is undertaken by Cedenco which would appear to be of advantage to new growers wishing to enter into a contract, but this means that growers with existing harvesting equipment have a large capital cost that cannot be easily recovered[1]. However, Cedenco has allowed some growers to continue harvesting and has offered to buy harvesters less than 5-8 years old[2].

Supplying an alternative processor, if one were available, is not possible because tomatoes are a heavy and perishable product. This was part of the reason why SPC Ardmona were careful about committing to production in the Burdekin as it would require a significant capital investment in processing capacity in the region. Following the closure of the Heinz processing plant at Echuca, there have been some attempts by growers to purchase the plant as a co-operative venture. To date, this has not been successful.

The only other producer of product from processing tomatoes is Billabong Produce in Jerilderie in southern NSW. Its output has declined from a little over 21,000 tonnes in 2009 to less than 10,000 tonnes in 2011, although this was a particularly poor production year

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[1] Australian Processing Tomato Grower's submission to ACCC 2 October 2011

[2] Cedenco's submission to the ACCC 7 November 2011

due to flooding. In 2010 they produced 17,000 tonnes from their own farms. Billabong produce does not contract processing tomatoes from other growers.

Production in Victoria was limited by drought in 2008 (151,000 t) season and 2011 was severely affected by flooding (as of 15 April 2011 the forecast for Australia was 85,000 t)[3].

The Australian market is also dominated by imported product. The world production of tomatoes for processing was 36.94 Mt in 2010 of which Australian production accounted for 265,000 t (< 1%). Processed tomato (whole or pieces) accounted for $34.793 M of imports into Australia in 2005/2006 and has been greater than $60 M in 2008/09 and 2009/10[4]. The gross value of Australian production was $27 M in 2005/06 and $18.5 M in 2007/08[4]. If the 2010/11 season had gone to plan then the production of 287,500 t would have been $31.6 M, however, it is likely to be less than $11 M[5].

At this stage with the loss of a major processor in the Goulburn Valley and in face of very cheap imports, it is unlikely that expansion of the industry in the Burdekin is likely to occur in the near future.

Production System

Processing tomatoes are grown without trellises using either drip of furrow irrigation. Seeds are usually raised in nurseries and transplants are used to establish the majority of the crop. Harvesting is mechanised with electronic colour sorters. Growth regulators may be used to promote uniform ripening.

Production in northern Victoria and southern New South Wales is undertaken through the summer with first plantings in early September, with production continuing through to final harvests in mid-April. An analysis of cropping systems for fresh tomato production in Queensland (Deuter 2011) identified that 29°C was a critical temperature for tomato production in terms of heat tolerance (with a range of 25°C to 32°C depending on the variety). The production systems for fresh tomatoes in the Lockyer Valley, Granite Belt and Bowen suggest that 29°C can be used as a good indicator of the limits to production in combination with the occurrence of frosts. The high temperature threshold takes into account a number of processes that result in low yield including flower drop, disruption of metabolic pathways and changes to plant architecture.

Response to temperature

Southern production region

Early season planting in southern Australia commences when the risk of frost is low in early September. Final plantings are limited by the onset of autumn with final harvests occurring in mid April. Using long term average meteorological data for Mooroopna in northern Victoria the average minimum monthly temperature when planting starts is about 6°C, and about 7-8°C when harvesting is finished (being more dependent on day time temperatures for developing fruit). Using data from 1957 to 2010 and projections for 2030 and 2050 using the AIFI scenario, it is possible to calculate the change in timing and duration of temperatures that exceed the threshold of 29°C and when the first planting threshold of 6°C is reached

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[3] World Processing Tomato Council (www.wptc.to)

[4] AusVeg website (www.ausveg.com.au)

[5] Australian Processing Tomato Research Council (www.aptrc.asn.au)

(Figures 1 and 2). This analysis was undertaken for four global circulation models (GCM), MIROC-H, CSIRO-MK35, CCCMA-47 and GFDL-21 from the data created under the Consistent Climate Change Scenarios project (version 1.1). Climate sensitivity was set to the inherent tuning of the GCM.

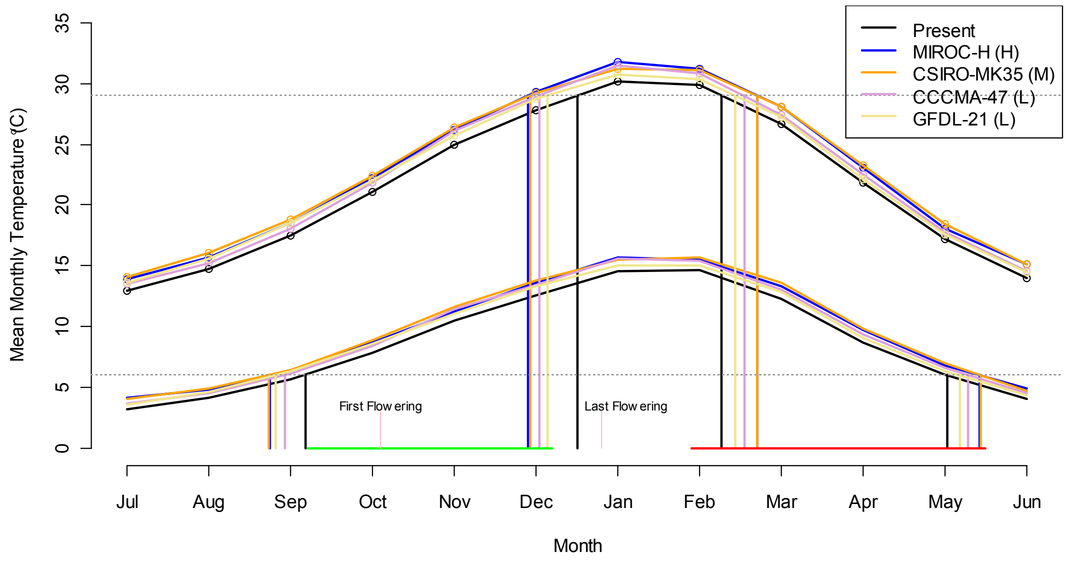

Figure 1. Critical period for tomato production at Mooroopna under present and future climate conditions for 2030 using A1FI scenario and inherent climate sensitivity. The current production window is marked by the green line: transplanting and red line: harvesting[6].

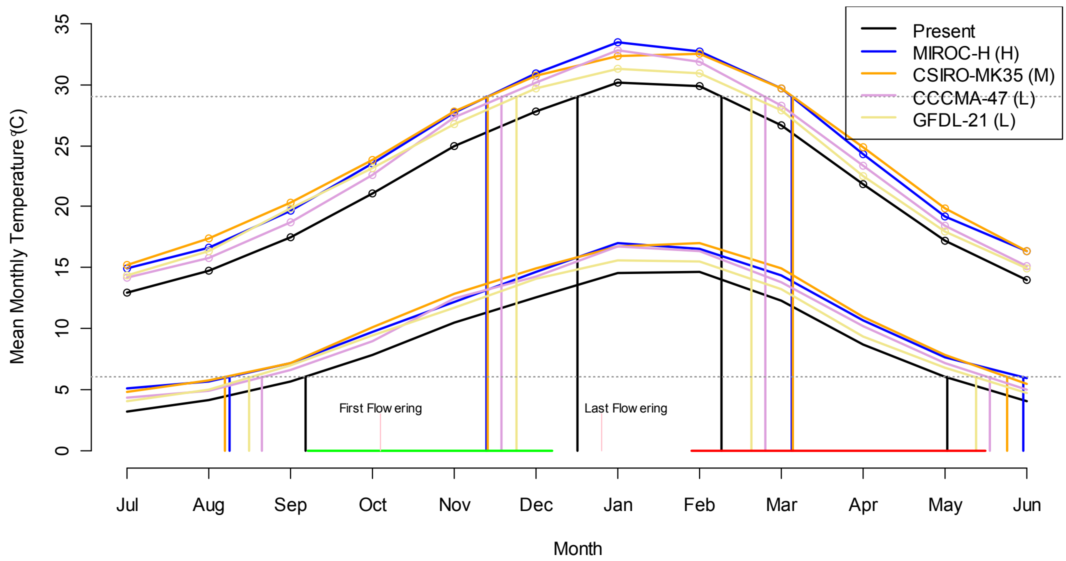

Figure 2. Critical period for tomato production at Mooroopna under present and future climate conditions for 2050 using A1FI scenario and inherent climate sensitivity. The current production window is marked by the green line: transplanting and red line: harvesting.

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6 Cedenco's submission to the ACCC 3 October 2011 (accessed 1 June 2012 http://goo.gl/e3BCc)

It is possible that some of the period in which yields are potentially reduced by higher temperatures may be offset by being able to start production earlier because of reduced frost risk and extend the period over which harvesting can continue. The latter is more difficult to determine as much of the flowering would still occur during the critical period when temperatures are above the threshold. The increase in the critical period of high temperatures in 2030 is in the range 16 to 32 days of which 7 to 14 days may be offset by starting production earlier depending on the model used. By 2050 the critical period increases, with a range of 33 to 60 days and an offset of 16 to 30 days (Table 1).

Table 1. Changes in the timing of critical events within the southern production system due to climate change A1FI scenario. Data period equivalent to 1957 to 2010.

	Maximum Temperatures > 29°C		Minimum Temperatures > 6°C	
Timescale and Model	**Exposure to high temperatures**	**Change compared to present conditions (days)**	**Time of first planting**	**Change compared to present conditions (days)**
Present	Mid Dec - early Feb		Early September	
2030				
CSIRO-MK35	Late Nov – late Feb	+ 30	Late August	-14
MIROC-H	Late Nov – late Feb	+32	Late August	-13
CCCMA-47	Early Dec – mid Feb	+23	Last Week of September	-7
GFDL-21	Early Dec – mid Feb	+16	Last week of August	-11
2050				
CSIRO-MK35	Early Nov – early March	+60	Early August	-30
MIROC-H	Early Nov – early March	+59	Early August	-28
CCCMA-47	Mid Nov – late Feb	+44	Mid August	-16
GFDL-21	Mid Nov – mid Feb	+33	Mid August	-21

Northern production region

In Northern Queensland, production for the fresh tomato market is a winter production system with transplanting occurring from February to early September and harvesting from June to early December. Thus the critical development phase is April to October when the majority of the flowering occurs. There are no frost problems and so production is constrained only by maximum temperatures (Figures 3 and 4). A reduction in the safe flowering window of 4 weeks by 2030 was expected in Bowen for fresh tomatoes (Deuter 2011).

The northern production of tomatoes for the fresh market occurs in the winter. This production system has been developed to capture the winter market, as well as to avoid the summer dominant rainfall. The winter is the dry season and so irrigation demand as a result of climate change may increase and become a limiting factor depending on the availability and price of irrigation water in the future.

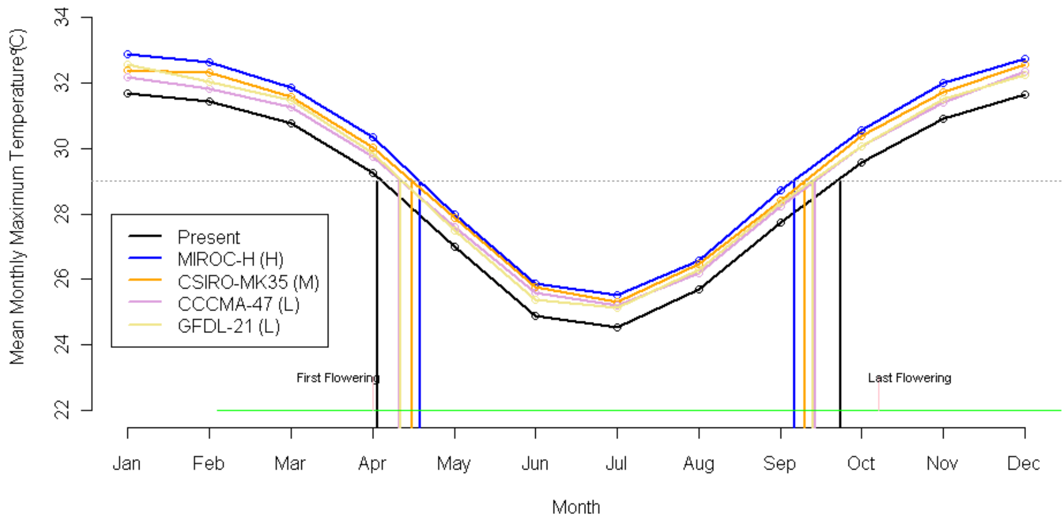


Figure 3. Critical period for tomato production at Bowen under present and future climate conditions for 2030 using A1FI scenario and inherent climate sensitivity. The current production window is marked by the green line.

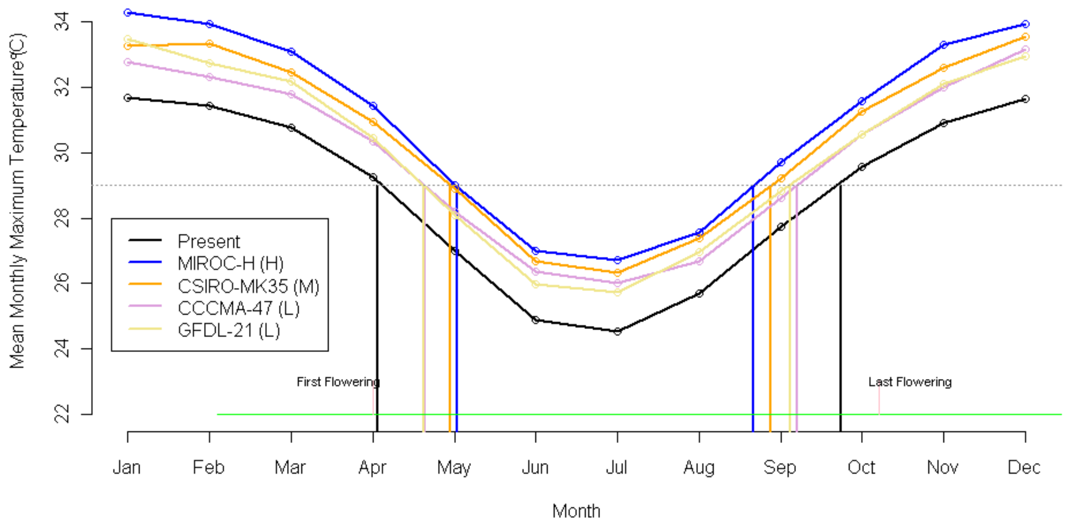


Figure 4. Critical period for tomato production at Bowen under present and future climate conditions for 2050 using A1FI scenario and inherent climate sensitivity. The current production window is marked by the green line.

As shown in Figure 3 and 4, the last flowering under the present climate occurs just within the timeframe where mean monthly maximum temperatures exceed 29°C with the final harvest about 9 weeks later in mid December. The first flowering time occurs at about the same time as the maximum temperature drops below the threshold. As temperatures increase due to climate change under the A1FI scenario there is likely to be a reduction in the growing days of between 17 to 33 by 2030 and 33 to 61 days by 2050 (Table 2).

Table 2. Changes in the flowering window in Bowen due to changes in maximum temperature under the A1FI scenario. Data period equivalent to 1957 to 2010.

Timescale and model	Flowering Window	Change compared to present conditions (days)
Present	Early Apr – late Sep	
2030		
CSIRO-MK35	Mid Apr – mid Sep	-26
MIROC-H	Mid-late Apr – early Sep	-33
CCCMA-47	Mid Apr – early Sep	-17
GFDL-21	Min Apr – mid Sep	-18
2050		
CSIRO-MK35	Late April – Late Aug	-53
MIROC-H	Early May – mid Aug	-61
CCCMA-47	Mid Apr – early Sep	-33
GFDL-21	Mid Apr – early Sep	-36

The current flowering window is about 180 days and so a reduction of up to 61 days by 2050 represents a third of production being lost. This would cause a dramatic reduction in the viability of the industry unless suitable cultivars can be found and used. These results for a larger number of GCMs confirm the conclusions drawn by Deuter (2011) for 2030.

Crop growth model

The DSSAT (Jones *et al.* 2003) system (version 4.02) was used to model production of processing tomatoes. This model has been used to model fertiliser and irrigation practices (Rinaldi *et al.* 2007) in southern Italy. For this study the model was parameterised with the SPC Ardmona trial undertaken at Euri Creek, near Bowen in 2010, an extension to the trials undertaken in 2009 (Mills 2010). Data collection was performed as part of the current study in collaboration with SPC Ardmona. Six varieties of tomato were used in the trials and the model was fitted to the average of the results so as to represent a generic processing tomato variety. The DSSAT model was parameterised using weather data collected at the site against the main phenological events and dry weight yield of tomatoes (Figure 5, Table 3). These parameters are show in Appendix 1.

Experimental simulations were undertaken for Bowen using the A1FI scenario and the CSIRO MK 3.5 and MIROC-H models. These models have a medium and high sensitivity to global warming. Simulations were undertaken using fortnightly planting dates throughout the year for the equivalent period of 1957 to 2009.

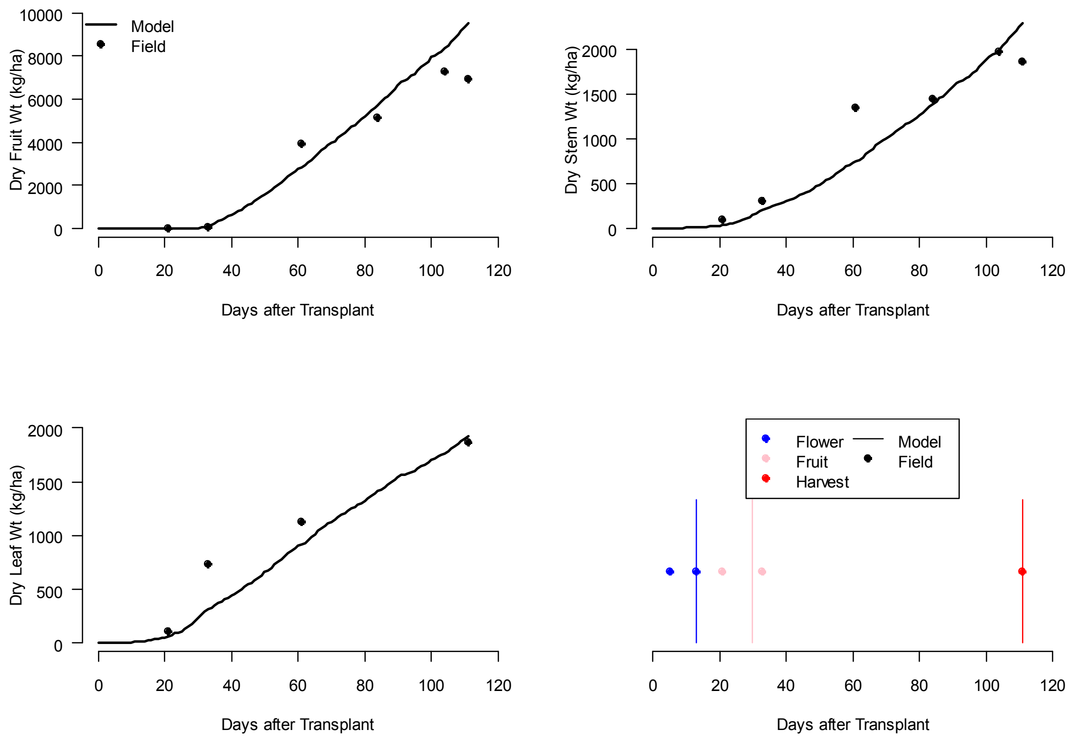


Figure 5. Modelled and field values for tomato trial conducted in Bowen 2010.

Table 3. Trial crop growth summary for Bowen 2010 and modelled values

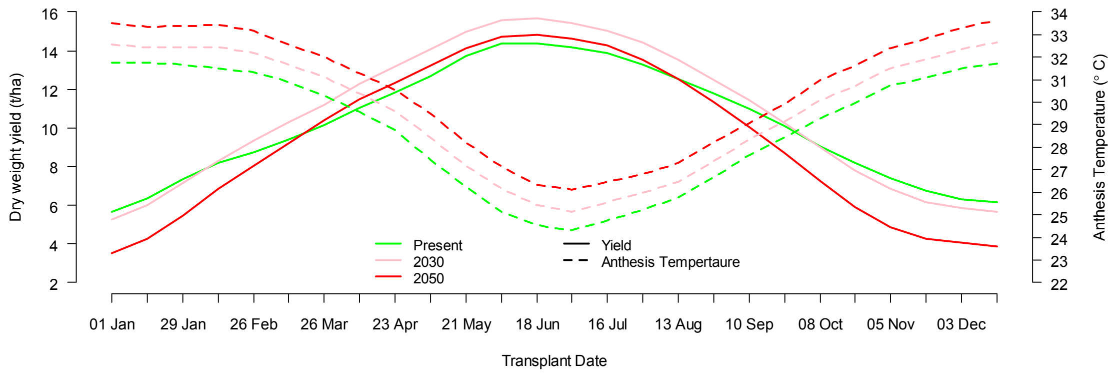
Event	Field Trial		Model
Sowing	24 April	-	-
Transplant	26 May	33 das	-
First flowers	31 May to 8 June	5 to 13 dat	13
First Fruit	16 to 28 June	21 to 33 dat	28
Harvest	13- to 14 September	110 to 111 dat	111
Yield (dry weight t//ha)		5.5 to 8.3	9.6

das – days after sowing; dat – days after transplant

Modelling crop growth in Bowen under climate change

The production window in Bowen for fresh tomatoes runs from February to mid-December under present conditions. Earlier studies have indicated that production is constrained by higher temperatures during the summer and so the risk under climate change is that the production window is decreased as the number of days that exceed the threshold temperature of 29°C increase. The study by Deuter (2011) on *fresh* tomatoes used a flowering date three to four weeks after transplanting. The trial shown above, Table 3, found that flowering occurred with five to thirteen days after transplant. Using the model for the growth of processing tomatoes we can recalculate the mean temperature for thirteen days prior to anthesis as discussed in Deuter (2011). Simulation of tomato growth was performed for 26 transplanting dates throughout the year, starting on 1 January and finishing on 17 December (Figure 6) with CO_2 set at 380 ppm. The threshold of 29°C is exceeded for early and late plantings and this is exacerbated under climate change. The number of weeks during which the threshold is not exceeded drops from 174 days under the present climate to 147 by 2030 and 117 days by 2050 using the CSIRO Mk 3.5 model and the AIFI scenario. This is in agreement with the threshold study undertaken by Deuter (2011) and the simplified analysis shown in Table 2, in that the safe flowering window is reduced by 28 days by 2030 by 57 days by 2050. Using the climate projections from the MIROC-H GCM there was a greater reduction in the flowering window: 138 days by 2030 and 110 days by 2050.

Under climate change and including the effect of CO_2 fertilisation (449 ppm in 2030 and 555



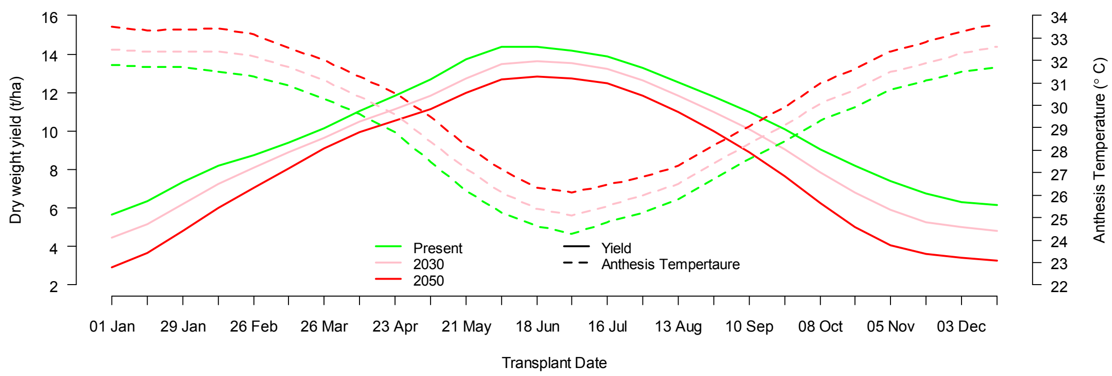


Figure 6. Mean yield and anthesis temperature for present and future climates as projected by the CSIRO Mk3.5 model and the AIFI scenario. Anthesis temperature calculated as mean of 13 days prior to predicted anthesis date. Climate data used for the equivalent period of 1957 to 1999. Top: including CO_2 fertilisation; Bottom: excluding CO_2 fertilisation

ppm in 2050) yields were initially increased in 2030 by 8% during the current production window and 12% by 2050 (Figure 6). This demonstrates the importance of using models to understand climate change impacts. Without the affect of CO_2 fertilisation the impact of climate change, i.e. higher temperatures, results in a 6% decrease in yield by 2030 and a 13% decrease by 2050. Using the MIROC-H GCM was more pronounced with the increase in yields being only 5% and 6% respectively. Without CO_2 fertilisation, these yields would be reduced by 9% and 18% for 2030 and 2050 respectively. Thus models that incorporate plant physiology can provide a far better understanding of the impacts of climate change. With high impact models such as MIROC-H the ability of the plant to cope with the increased temperatures cannot be offset by the higher levels of CO_2. While the analysis using the crop model is an important additional step towards understanding the impact of climate change on crop production, it remains relatively simplistic.

The profitability of a farming enterprise requires a more detailed farm level study and a greater amount of field work to be able to assess the impact of irrigation requirements and costs and the impact of pests and diseases under climate change. Furthermore, the response to CO_2 needs to be carefully studied for a wider range of crops, production systems and climate impacts as the interactions between them need to be understood.

Further development of crop models for application to horticulture within the APSIM/APSFarm framework (McCown *et al.* 1995; Power *et al.* 2011) should be considered a high priority. This would offer greater access to Australian soil parameters and climate data via the SILO facility (Jeffrey *et al.* 2001) especially as this will integrate the output from climate models in the future and so provide a seamless platform on which to undertake detailed studies of the impact of climate change on horticultural production systems.

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Appendix 1. Cultivar parameters used in the DSSAT Cropgro model for tomatoes

DSSAT Code	Description	Value
EM-FL	Time between plant emergence and flower appearance (R1)(photothermal days)	14.5
FL-SH	Time between first flower and first pod (photothermal days)	8.0
FL-SD	Time between first flower and first seed (photothermal days)	17.0
SD-PM	Time between first seed and physiological maturity (photothermal days)	42
FL-LF	Time between first flower and end of leaf expansion (photothermal days)	50
LFMAX	Maximum leaf photosynthesis rate at 30ºC, 350 vpm CO_2, and high light(mg CO_2/m2-s)	3.5
SLAVR	Specific leaf area of cultivar under standard growth conditions(cm2/g)	400
SIZLF	Maximum size of full leaf (three leaflets) (cm2)	300
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	0.7
WTPSD	Maximum weight per seed (g)	0.004
SFDUR	Seed filling duration for pod cohort at standard growth conditions (photothermal days)	2625
SDPDV	Average seed per pod under standard growing conditions (#/pod)	300
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photothermal days)	5421