Effect of planting date on vegetative growth in greenhouse tomato crops

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Abstract

Leaf length, stem diameter and shoot growth in three June and two September, February and March plantings of tomato cv. Conqueror were measured every 14 days during the life of each crop. Crops were grown using a deep flow technique growing system in twin-skin polythene greenhouses. Leaf length and stem diameter readings were similar to Dutch guidelines for much of the life of the June plantings but were not in the other plantings. Shoot growth increments were similar to the Dutch guidelines. Possible causes of seasonal and between country differences are discussed.

Additional key words: cv. Conqueror, deep flow technique growing system, twin-skin polythene greenhouses.

Introduction

Year round tomato (*Lycopersicon esculentum* L.) greenhouse production is achieved in the Auckland region and, in many other parts of New Zealand (HortNZ, 2007) through the use of a range of planting times. Thus, throughout a year, plants of different ages and crop loads are exposed to different light and temperature environments. We could, therefore, expect different patterns of vegetative growth to be seen at different planting times.

In this study we recorded leaf length, stem diameter and shoot growth in a sample of plants of every planting of one cultivar in two neighbouring, greenhouses from June 2004. These measurements are used by consultants (including Canadian advisors) (Portree *et al.*, 1996) and the Substratus Horticultural Crop Consultancy of Holland, one of the world's largest greenhouse vegetable crop consultancy companies) and growers to monitor and compare tomato crops (but not widely in New Zealand).

Our purpose was to retrospectively examine rather than monitor growth. We wished to identify differences in growth patterns at different planting times and to compare our results with the guidelines in Northern Hemisphere crop registration tools, e.g. those of the Substratus Horticultural Crop Consultancy (http://www.grodan.com/sw10039.asp).

Results from winter, spring, late summer and early autumn plantings are described and discussed.

Materials and Methods

This study was conducted on plants in commercial crops growing in two double plastic covered greenhouses (termed houses A and B) at Waimauku (36° 46' S, 174° 30' E), in Rodney County, New Zealand). The greenhouses were similar in size (4,000 m^2), construction, growing systems (using deep flow technique), planting density, venting and heating set points, humidity settings, radiation received, irrigation treatments, electrical conductivity (EC), nutrition and crop management systems.

Total daily incoming solar radiation measurements from the Henderson Meteorological Station, about 15 km from the greenhouse site, were used as a measure of light conditions during the study.

Photosynthetically active radiation in the greenhouses was estimated to be about one third of total incoming solar radiation. Long-term total incoming solar radiation records from the Pukekohe Meteorological Station (about 70 km distant) were also consulted (Figure 1), as 30 year long term records are not available from Henderson.

Measurements were taken every 14 days from 10 plants in all plantings from June 2004 (Table 1) of cv. Conqueror (a plum-shaped tomato) of:

- Leaf length just above the fourth truss down from the apical bud (or the lowest truss in very young plants)
- Main stem diameter (measured at right angles to where the stem of the fourth truss down from the apical bud (or lowest truss in very young plants) attached to the main stem)
- Plant height.

Table 1. Planting and final harvest dates, crop longevity, radiation and final plant height for greenhouse tomato crops between June 2004 and April 2007.

House	Planting Date	Final Harvest	Longevity (days)	Radiation (MJ m^{-2})	Final Plant Height (m)
B	18 Jun 04	1 Jun 05	348	4,809	10.44
B	28 Jun 05	9 Mar 06	254	3,977	7.58
A	28 Jun 05	25 Jan 06	211	3,203	5.80
A	17 Feb 05	13 Jul 05	150	1,669	4.28
A	5 Feb 06	24 Aug 06	200	2,112	5.38
A	15 Mar 06	16 Nov 06	246	2,674	7.02
B	17 Mar 06	24 Aug 06	160	1,392	3.79
A	12 Sep 06	22 Mar 07	191	3,495	6.12
B	12 Sep 06	19 Apr 07	219	3,835	5.85

The first measurements of plant height were taken from the lip of the growing trough to the top of the plant. When the stem between the trough lip and the first truss had stopped expanding, the distance from the first truss to the top of the plant was measured in the greenhouse and the trough to first truss distance added later when the results were keyed into a spreadsheet. At each recording day after harvesting commenced the distance from the lowest truss carrying fruit at the previous measurement to the new lowest truss carrying fruit was measured. Then the distance from the new lowest truss carrying fruit to the top of the plant was also measured.

Graphs were plotted of leaf length, stem diameter or shoot growth increment in 14 days of the mean of the 10 measured plants versus days from planting. The final mean plant height in each planting was plotted against days from planting and a regression fitted. Smooth curves were fitted to scatter plots using the loess function (Cleveland *et al.*, 1992). Plots, regression line and smoothing curve fitting were carried out using the R statistical package (R Development Core Team, 2007).

Results and Discussion

(a) Seasonal changes in radiation

The long-term radiation records from Pukekohe meteorological station are summarised in Figure 1. On average, light intensity at the brightest part of mid-summer is nearly twice as high as in the dullest period of mid-winter. The low light intensity of mid-July at Pukekohe or an even lower light intensity prevails for about 4 months in the main greenhouse growing regions of Holland (Nederhoff, 2001). Summer light intensities in Holland are also lower than in the Auckland region of New Zealand (Nederhoff, 2001). These differences in the light environment in New Zealand may create variations in crop

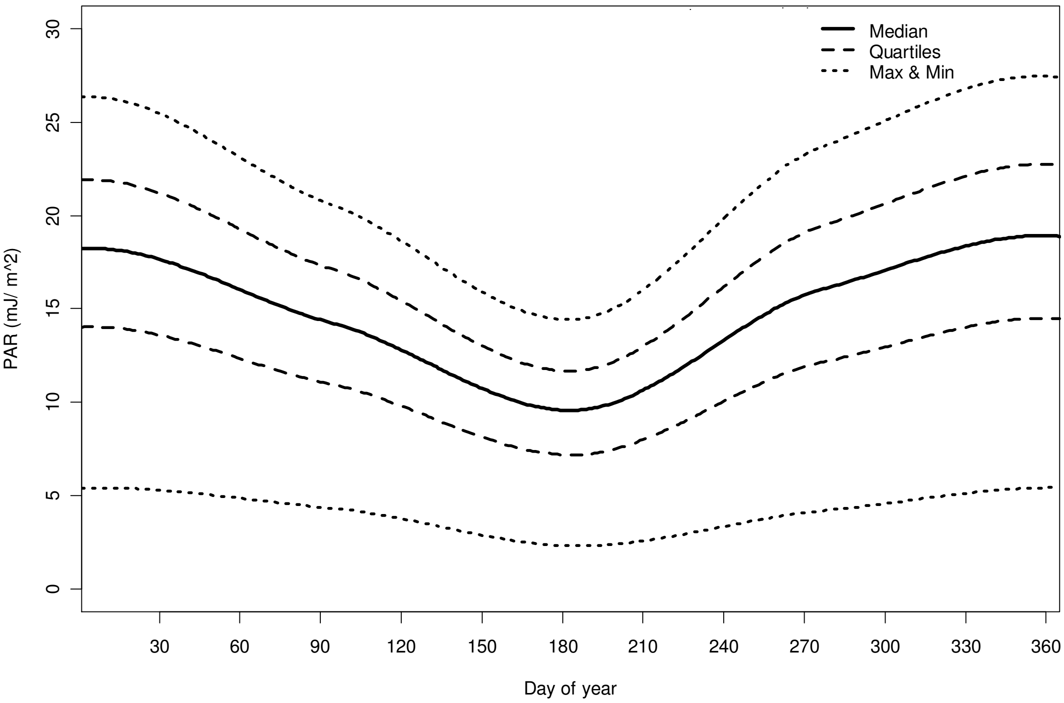

Figure 1. Long term (1972-2003) total daily incoming radiation at Pukekohe meteorological station. Smoothed curves fitted to daily traces.

growth from that experienced in Holland; this may require crop growth measurement guidelines used for crop registration to be adapted for New Zealand use.

(b) Leaf length and stem diameter

In the June plantings young plants had longer leaves (Figure 2) and larger stems (Figure 3) than older plants. Plantings with the most vigorous young plants tended to have the longest life (Figure 2, 3, Table 1). Leaf length was within the Substratus guideline of 400 to 450 mm for high light intensity areas in the two longest living June plantings while leaf length in the shortest living June planting was mostly within the Substratus guideline of 350 to 400 mm for a low light intensity area. Stem diameter was below the Substratus guideline of 11 to 12 mm in June plantings up to about seven weeks after planting. It was then mostly above the guideline in the 2004 planting and was within the guideline in the 2005 plantings.

In September, February and March plantings, both leaf length (Figure 2) and stem diameter (Figure 3), in young plants, reached a pronounced peak at about 50 days after planting. Leaf length, later in the life of the crop, was more often in the Substratus guidelines in September and March plantings than in the February plantings. Only two measurements, in the March planting, in House B, were below the Substratus guidelines. Stem diameter in September plantings was above the Substratus guideline from planting to early autumn. It was within the guideline in late autumn and below it in early winter. Stem diameter in February and March plantings was above the Substratus guideline for 1 to 3 months after planting. It was below the guideline in winter and returned above the guideline in spring in the long-lived March planting.

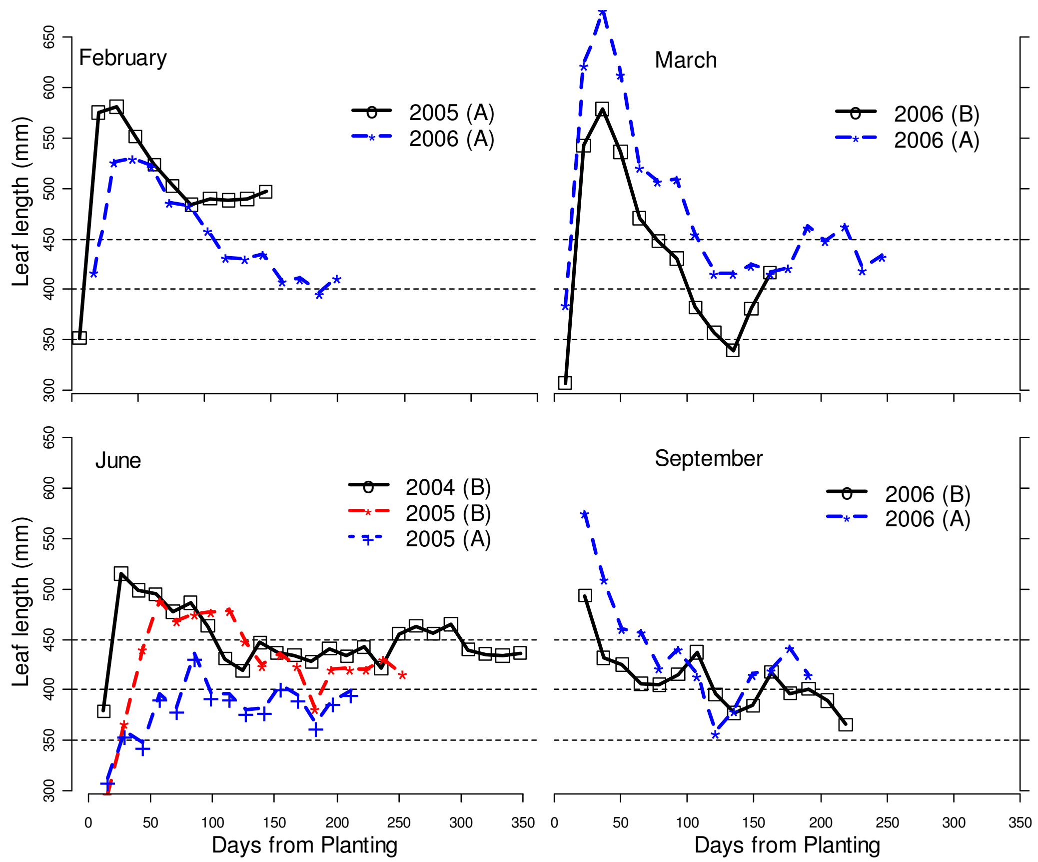

Figure 2. Length (mm) of leaf above the 4th truss from the top of the plant at 14-day intervals in February, March, June and September plantings.

(c) Plant height

Shoot growth increments in 14 days oscillated around the Substratus guideline of 0.4 m at most recording times in all plantings until plants were topped by the grower prior to the final harvests (Figure 4). The largest increments in all plantings (over 0.5 m in 14 days) occurred between late spring and early autumn, suggesting that shoot growth was not inhibited by the high light intensities prevailing in the greenhouses. Heuvelink (1996) also found that light saturation did not occur in tomatoes, even at high natural light intensities. Sustained periods of small increments (less than 0.3 m in 14 days) occurred in the two shortest-lived crops (House A, February 2005 planting and House B, March 2006 planting) and were probably due to plant health issues rather than to low light intensity.

We were surprised there was so little seasonal variation in shoot growth rate in this study given that higher light intensities and temperatures increased leaf initiation rates in the work of Kinet and Peet (1997). Our results indicate that some ‘stretching’ of plants may be occurring in the September and February plantings in the short duration, low light intensity winter days (Figure 4). June planted crops only marginally increase their growth rate once radiation intensity and duration increased in spring and summer, possibly due to a greater crop load at that time.

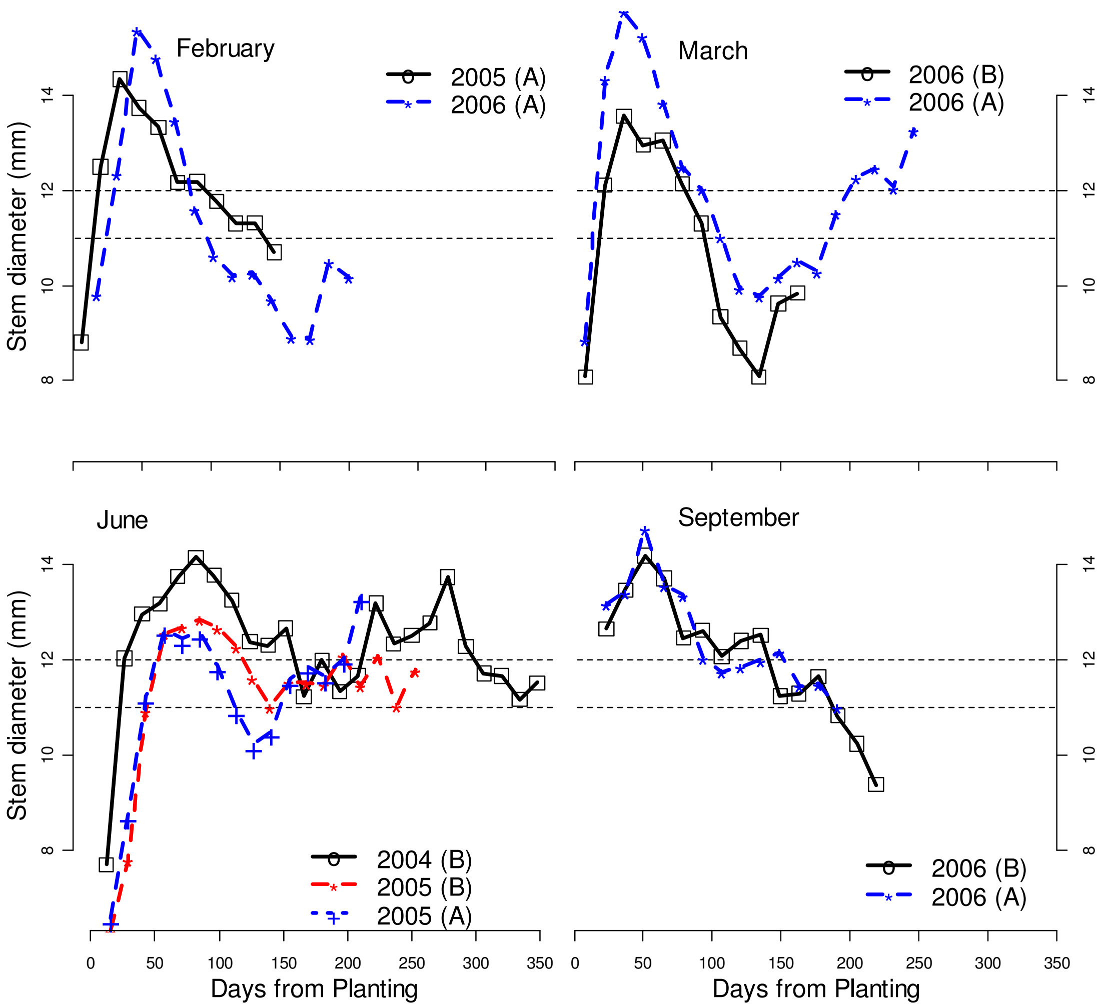

Figure 3. Stem diameter (mm) at the 4th truss from the top of the plant at 14-day intervals in February, March, June and September plantings.

The relatively consistent shoot growth increments throughout most of the life of all plantings were reflected in a strong linear relationship (r^2 = 95.9 %) when final plant height of each planting is plotted against days to the end of cropping (Figure 5). From the slope of the regression we estimate that every 14 days the plant increased in height by 402 mm (s.e. 9.5, $p < 0.001$). This estimate is very close to the Substratus guideline of 0.4 m.

The Substratus guidelines and, presumably, Dutch models generally fit New Zealand June plantings better than those in other months. Adjustment of these crop growth guidelines to better reflect balanced growth in New Zealand crops planted at other times of the year is needed. Information from other New Zealand crops grown in other situations, e.g. under glass, in different growing systems or media, or using other cultivars is required for the further development of New Zealand guidelines and models.

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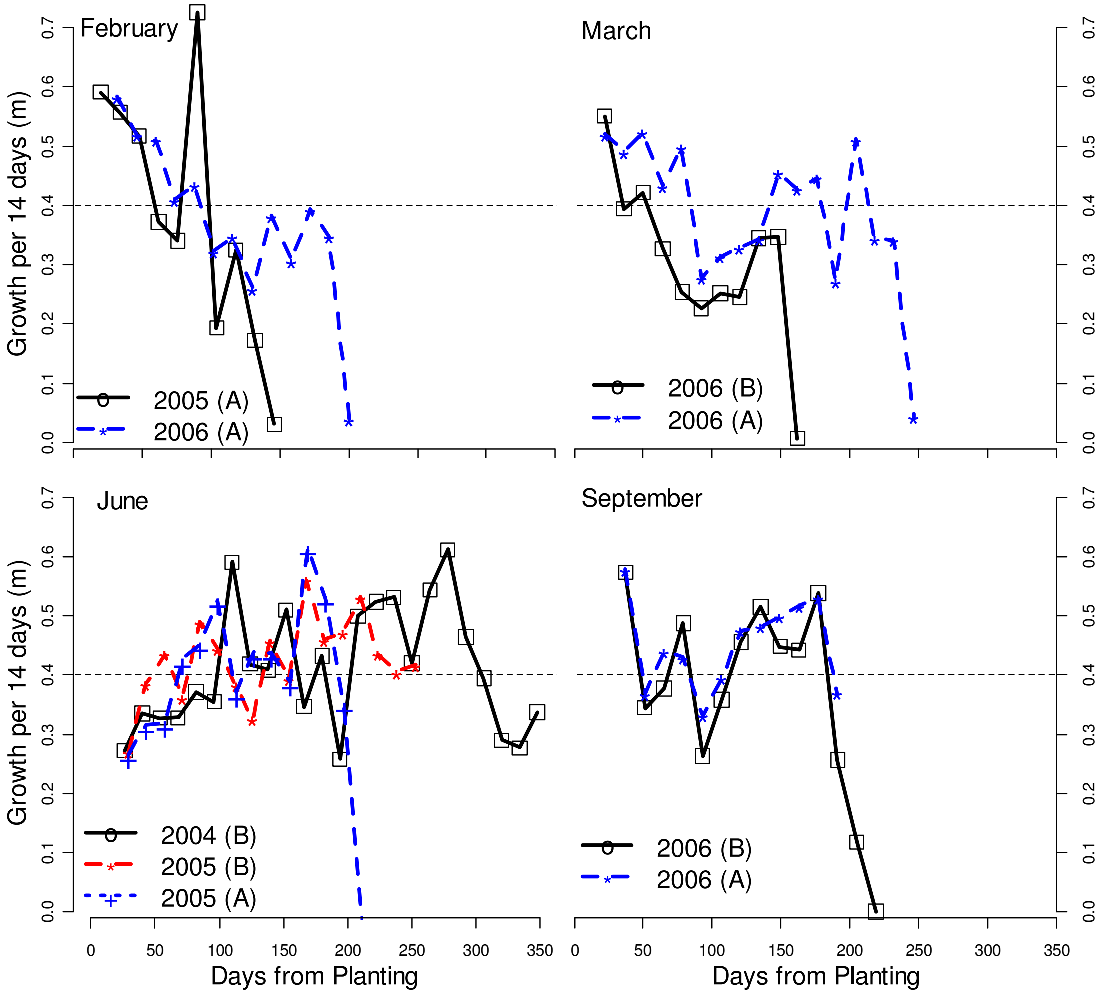

Figure 4. Shoot growth increment (m) between measurements at 14-day intervals in February, March, June and September plantings (note no growth after the grower tops plants prior to final harvests was recorded in all February and March plantings and only two of the five crops in June and September plantings).

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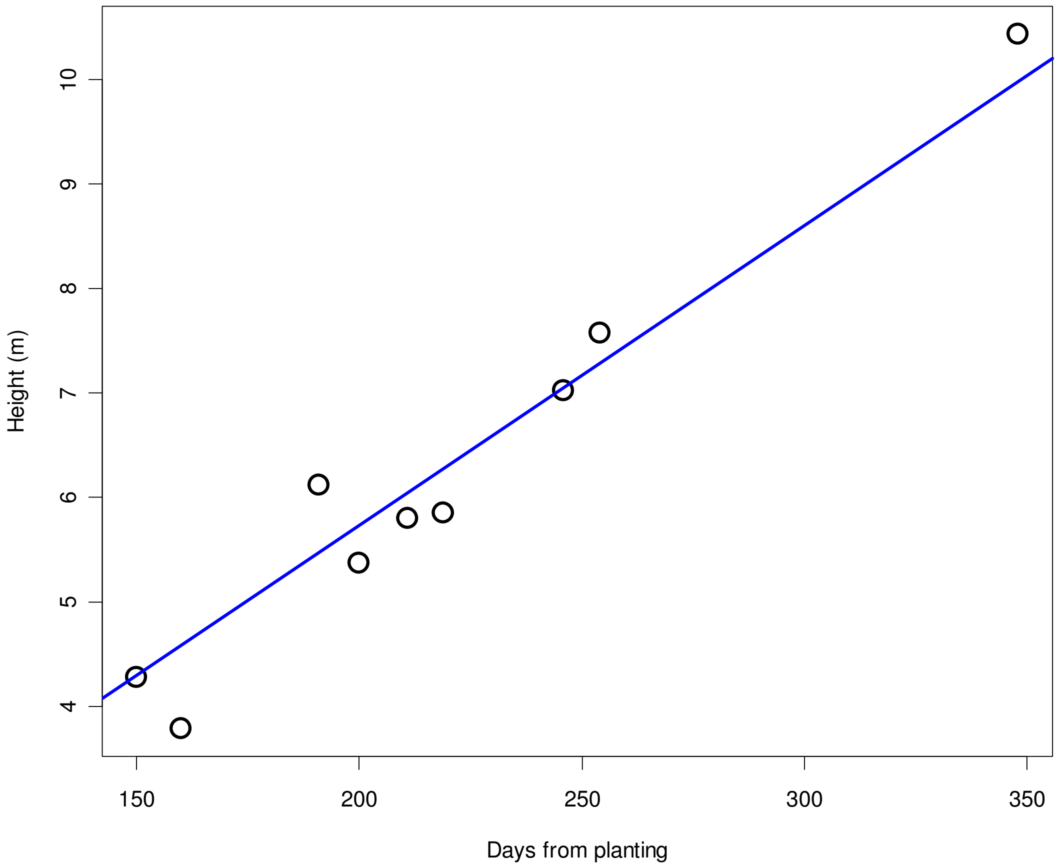

Figure 5. Final plant height (m) of each planting plotted against days from planting to the end of cropping.