

DIFFERENCES IN THE RESPONSE OF STRAWBERRY CULTIVARS TO CHILLING AND SUBSEQUENT GROWTH UNDER HIGH TEMPERATURE CONDITIONS

NADINE A. LEDESMA^{1*}, CYRIL S. RAGAY², JUSTIN C. DELGADO² AND DANILO P. PADUA³

¹Department of Biology, De La Salle University, Manila, Philippines

²AgriVet Sciences Institute, De La Salle Araneta University, San Jose del Monte, Bulacan, Philippines

³Department of Agronomy, Benguet State University, La Trinidad, Benguet, Philippines



BACKGROUND

- Short-day or June-bearing, day-neutral and everbearing
- Short-day cultivars are sensitive to photoperiod and temperature interaction for flower induction
- Photoperiod: $<14\text{h}$; Temperature: $\leq 15^{\circ}\text{C}$
- Photoperiod x Temperature requirements vary by cultivar: $\downarrow$ ($\uparrow$) photoperiod; $\uparrow$ ($\downarrow$) temperature except $\geq 25^{\circ}\text{C}$

BACKGROUND

- Chilling requirement - breaks dormancy; enhances vegetative vigor and fruit production in SD cultivars
- Occurs naturally in the field
- Done artificially for uniform growth and flowering
- 0° to 7° C in the dark or under short daylengths for weeks to months
- Requirement varies by cultivar

BACKGROUND: Effect of Chilling

Number of chilling hours affect plant vigor after dormancy period:

- Too little: enhanced vegetative growth; fewer flowers
- Too much: delayed initiation of new flowers
- Adequate: Balance of vegetative and reproductive growth - enough leaves to support flowers and fruits; sufficient flower initiation

SIGNIFICANCE OF THE STUDY

- Interest in growing strawberries under tropical conditions: Davao, Iloilo, Cebu, Bataan, Pampanga and Bulacan.
- Fruits are small; Fruit set is low.
- Concern for the effect of increasing global temperatures on production of temperate crops



OBJECTIVES

Can chilling improve plant vigor enough to counteract the effect of high temperature growing conditions?

- 1) Determine whether chilling can enhance the vegetative and reproductive performance of strawberry at high temperature growth conditions;
- 2) Compare responses of strawberry cultivars to chilling and subsequent growth at high temperatures

METHODOLOGY

- Runners obtained from Benguet State University (3) and a commercial grower in Metro Manila (1)
- Cultivars: Toyonoka x (Fern x Toyonoka); BSU Pierre; Fern x Strawberry Festival; Hawaiian
- Runners planted in open field at Salikneta Farm, Bulacan in July and served as mother plants
- Runners from mother plants rooted in garden soil + coir

METHODOLOGY

- Chilling Treatment: 6 d (144 h) at 4 - 5°C
- Ambient, high temperatures, partial shade (4 d)



METHODOLOGY

- Strawberry plants in open-field plots
- More chilling: increase in leaf number, leaf size, runner production
- Less chilling: fewer flowers, smaller and fewer fruits
- Adequate chilling: more and bigger leaves, fewer runners, more flowers, better fruits



RESULTS: TEMPERATURE AND PHOTOPERIOD

Figure 1. Average hourly temperature (°C) at experiment site for the entire duration of the study.

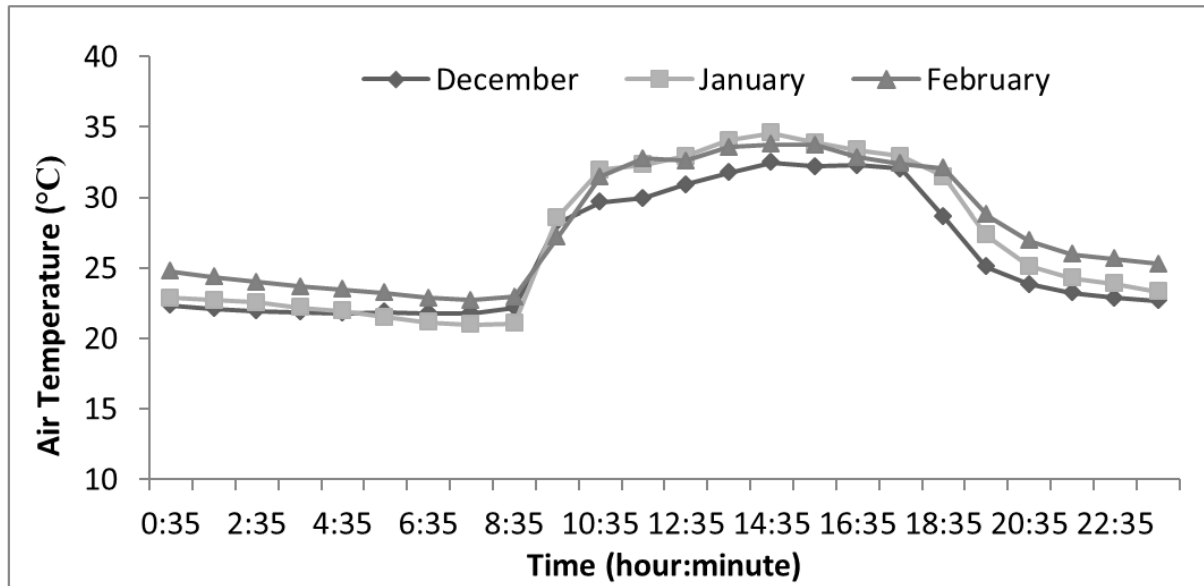


Table 1. Average photoperiod from August 2015 to February 2016 at the experiment site.

Month	Average Day length (h:m:s)
2015	
August	12:36:10
September	12:12:52
October	11:48:37
November	11:27:45
December	11:17:00
2016	
January	11:22:08
February	11:39:56

*Source: (http://aa.usno.navy.mil/data/docs/RS_OneYear.php).

Effect of chilling on number of leaves

Table 2. Number of leaves of four strawberry cultivars ten weeks after transplanting in the field.

Cultivar	Number of Leaves		<i>p</i>
	Unchilled	Chilled	
“TFT”	7.40 a	16.90 a	0.001
‘BSU Pierre’	6.40 a	10.50 b	0.021
“FSF”	3.80 b	3.00 c	0.166
‘Hawaiian’	16.19 c	25.22 d	0.023

*Same letters within a column indicate non-significance.
p values are for Unchilled vs. Chilled.

Effect on Runners and Branch Crowns

Table 3. Number of runners and branch crowns produced by four strawberry cultivars ten weeks after transplanting in the field.

Cultivar	Number of Runners			Number of Branch Crowns		
	Unchilled	Chilled	<i>p</i>	Unchilled	Chilled	<i>p</i>
“TFT”	0.00 a	0.80 a	0.121	2.50 a	3.60 ac	0.094
‘BSU Pierre’	1.00 ab	0.60 a	0.513	0.90 b	2.70 a	0.003
“FSF”	1.20 b	0.78 a	0.322	0.50 b	0.44 b	0.820
“Hawaiian”	2.08 b	3.00 b	0.245	3.11 a	4.56 c	0.038

* Same letters within a column indicate non-significance. *p* values are for Unchilled vs. Chilled.

Effet on flowering and fruit set

Table 4. Mean number of flowers and fruits from four strawberry cultivars.

Cultivar	Number of flowers			Number of fruits			Fruit set (%)		
	Unchilled	Chilled	<i>p</i>	Unchilled	Chilled	<i>p</i>	Unchilled	Chilled	<i>p</i>
“TFT”	11.0a	11.6a	0.795	6.6a	2.0a	0.018	62.2a	14.6a	0.010
‘BSU Pierre’	10.7a	9.7b	0.468	3.3b	2.3a	0.709	35.2b	23.3b	0.667
“FSF”	3.3b	11.7a	0.035	1.0c	2.0a	0.482	20.0c	21.1b	0.956
“Hawaiian”	13.3c	0.0c	0.001	8.0a	0.0b	0.010	59.9a	0.00c	0.005

* Same letters within a column indicate non-significance. *p* values are for Unchilled vs. Chilled.

Effect on fruit

Table 5. Length, diameter, weight and soluble solids content of fruits of four strawberry cultivars.

Cultivar	Length (cm)			Diameter (cm)		
	Unchilled	Chilled	<i>p</i>	Unchilled	Chilled	<i>p</i>
“TFT”	2.44 a	1.94 a	0.015	2.10 a	1.78 a	0.166
‘BSU Pierre’	1.97 b	2.52 b	0.021	1.78 a	2.40 b	0.001
“FSF”	2.27 ab	2.69 b	0.097	2.04 a	2.34 b	0.317
“Hawaiian”	2.03 ab	none		1.76 a	none	
Cultivar	Weight (gm)			SSC (°Brix)		
	Unchilled	Chilled	<i>p</i>	Unchilled	Chilled	<i>p</i>
“TFT”	8.4 a	5.67 a	0.109	6.31 a	6.92 a	0.249
‘BSU Pierre’	4.9 b	10.43 b	0.000	8.54 b	7.08 a	0.003
“FSF”	10.0 a	10.33 b	0.867	8.97 b	9.58 b	0.306
“Hawaiian”	9.1 a	none		6.41 a	none	

* Same letters within a column indicate non-significance of means.

SSC – soluble solids content. *p* values of Unchilled vs. Chilled.

Summary of Findings

Cultivar	Leaves	Runners	Branch Crowns
Tx(FxT)	**	NS	NS
BSU Pierre	*	NS	**
FxSF	NS	NS	NS
Hawaiian	*	NS	*

Cultivar	% Fruit Set	Weight	Diameter	Length	°Brix
Tx(FxT)	*	NS	NS	*	NS
BSU Pierre	NS	**	**	*	** (↓)
FxSF	NS	NS	NS	NS	NS
Hawaiian	** (↓)	-	-	-	-

KEY FINDINGS

- The effect of chilling on the vegetative and reproductive growth of strawberry varies
- Cultivars respond differently to chilling and subsequent planting at high temperatures.
- Chilling can possibly be used to alleviate or improve the fruiting and fruit quality of certain short-day cultivars

RECOMMENDATIONS

- Optimum chilling conditions for these and other SD cultivars need to be determined.
- It may also be of interest to strawberry growers in the highlands to expose runners to a chilling treatment prior to planting in the open field.
- Study dormancy and the optimum photoperiod x temperature conditions in the Philippines to maximize production under highland conditions

REFERENCES

1. AVIGDORI-AVIDOV H, GOLDSCHMIDT EE, KEDAR N. 1977. Involvement of endogenous gibberellins in the chilling requirements of strawberry (*Fragaria x ananassa* Duch.). *Annals of Botany* 41: 927-936.
2. BECKLES DM. 2012. Factors affecting the postharvest soluble solids and sugar content of tomato (*Solanum lycopersicum* L.) fruit. *Postharvest Biology and Technology* 63(1): 129-140.
3. DARROW GMM. 1966. *The Strawberry: History, Breeding, and Physiology*. California: Holt, Rinehart and Winston. 515 p.
4. HANCOCK JF. 1999. *Strawberries*. New York: CABI Publishing. 237 p.
5. HEIDE OM. 1977. Photoperiod and temperature interactions in growth and flowering of strawberry. *Physiologia Plantarum* 40: 21-26.
6. KADIR S, SIDHU G, AL-KHATIB K. 2006. Strawberry (*Fragaria x ananassa* Duch.) growth and productivity as affected by temperature. *Hortscience* 41(6): 1423-1430.
7. KONSIN M, VOIPIO I, PALONEN P. 2001. Influence of photoperiod and duration of short-day treatment on vegetative growth and flowering of strawberry (*Fragaria x ananassa* Duch.). *The Journal of Horticultural Science and Biotechnology* 76(1): 77-82.
8. KRONENBERG HG, WASSENAAR LM. 1972. Dormancy and chilling requirement of strawberry varieties for early forcing. *Euphytica* 21(3): 454-459.
9. LEDESMA NA, NAKATA M, SUGIYAMA N. 2008. Effect of high temperature stress on the reproductive growth of strawberry cvs. 'Nyoho' and 'Toyonoka'. *Scientia Horticulturae* 116(2): 186-193.
10. LE MIÈRE P, HADLEY P, DARBY J, BATTEY NH. 1998. The effect of thermal environment, planting date and crown size on growth, development and yield of *Fragaria x ananassa* Duch. cv. Elsanta. *The Journal of Horticultural Science and Biotechnology* 73(6): 786-795.

REFERENCES

11. LE MIÈRE P, HADLEY P, DARBY J, BATTEY NH. 1996. The effect of temperature and photoperiod on the rate of flower initiation and the onset of dormancy in the strawberry (*Fragaria x ananassa* Duch.). *Journal of Horticultural Science* 71(3): 361-371.
12. LIETEN P. 2009. Chilling requirement of strawberry cv. 'Sonata' and 'Figaro'. *Acta Horticulturae*. 842: 749-752.
13. LIETEN P, KINET J, BERNIER G. 1995. Effect of prolonged cold storage on the production capacity of strawberry plants. *Scientia Horticulturae* 60: 213-219.
14. PIPATTANAWONG R, YAMANE K, FUJISHIGE N, BANG S, YAMAKI Y. 2009. Effects of high temperature on pollen quality, ovule fertilization and development of embryo and achene in 'tochiotome' strawberry. *Journal of the Japanese Society for Horticultural Science* 78 (3): 300-306.
15. POLING EB. 2012. Strawberry plant structure and growth habit. New York State Berry Growers Association, Berry EXPO (handout) Cornell University, Ithaca, NY.
16. SØNSTEBY A, HEIDE OM. 2008. Temperature responses, flowering and fruit yield of the June-bearing strawberry cultivars Florence, Frida and Korona. *Scientia Horticulturae* 119(1): 49-54.
17. STRAND LL. 1993. Integrated Pest Management for Strawberries. Oakland, CA: University of California Division of Agriculture and Natural Resources.
18. TEHRANIFAR A, MIERE PL, BATTEY NH. 1998. The effects of lifting date, chilling duration and forcing temperature on vegetative growth and fruit production in the Junebearing strawberry cultivar Elsanta. *The Journal of Horticultural Science and Biotechnology* 73(4): 453-460.
19. YAMASAKI A. 2013. Recent progress of strawberry year-round production technology in Japan. *JARQ* 47 (1): 37-42.

THANK YOU

