

# Determining Thermotolerance in Ornamental Pepper Cultivars

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## Introduction and Rationale

- Ornamental peppers (*Capsicum annuum* L.) are widely used as potted flowering and bedding plants
- They are grown as summer annuals for their attractive fruit and foliage
- Temperatures above 90°F inhibit fertilization process of flowers
- High temperatures may cause a reduction in fruit set and reduce aesthetic and commercial value
- Future projected climate change will exacerbate the high temperature effects on fruit set
- Reproductive organs are more sensitive to high temperature than vegetative organs
- It is important to screen and develop new cultivars of ornamental peppers tolerant to major environmental stresses like high temperature

## Objectives

- Quantify ornamental pepper cultivars' *in vitro* pollen germination and pollen tube growth responses to temperature
- Determine cultivar-specific cardinal temperatures based on pollen parameters
- Determine the correlation between pollen based parameters and cell membrane thermostability
- Classify the cultivars for thermotolerance using pollen based parameters and cell membrane thermostability

## Materials and Methods

Cultivars used:

- Twelve ornamental pepper cultivars were grown in the greenhouse

1. 'Black Pearl'	4. 'Explosive Ember'	7. 'Red Missile'	10. 'Thai Hot'
2. 'Calico'	5. 'Medusa'	8. 'Salsa Yellow'	11. 'Treasures Red'
3. 'Chilly Chili'	6. 'Purple Flash'	9. 'Sangria'	12. 'Variegata'

Growth Conditions:

- Growth period: May – July, 2009
- Pot size and media: 1 L plastic pots; "Pro-Mix" Bx W/Mycorise growth media
- Irrigation and fertilization: Peter's 20-20-20 applied at 200 ppm daily as needed
- Temperature: Day venting temperature 75°F (averaged 79 ± 6°F)
- Flower collection for pollen: Between 09:00 and 10:00 h

Measurements:

### Reproductive Parameters

- Pollen viability - Tetrazolium test
- Pollen Germination (PG) and Pollen Tube Length (PTL)
- Pollen grains were spread on to the modified pollen germination medium (Reddy and Kakani, 2007) in Petri-dishes
- Pollen grains were cultured and exposed to eight temperature treatments from 50 to 104°F at 9°F interval, with four replicates for each treatment

### Physiological Parameter

- Cell membrane thermostability (CMT) (Martineau et al.1979)

Curve fitting and analysis

- Bilinear and quadratic regression models were used to analyze the data on pollen germination and tube length

Cardinal temperatures determination

- Cardinal temperatures (minimum, optimum and maximum) for both PG and PTL were derived from the models

### Ornamental Peppers Grown in Greenhouse



## Data Analysis

- Ornamental pepper cultivars were classified for temperature tolerance based on following parameters:

1. Pollen viability (%) = PV%	4. Maximum pollen tube length (µm) = PTL
2. Maximum pollen germination (%) = PG%	5. Cell membrane thermostability (%) = CMT
3. Cardinal temperatures (T <sub>min</sub> , T <sub>opt</sub> , T <sub>max</sub> ) for both PG and PTL (°C)	

- Individual stress response indices (ISRI) and then cumulative temperature response indices (CTRI) were calculated based on above 10 parameters.

$$ISRI (Heat) = P_i / P_o$$

$$ISRI (Cold) = P_o / P_i$$

$$Heat\ CTRI = \left( \frac{PV\%_i + PG\%_i + PTL_{\mu m}_i + PG_{T_{min}} + PG_{T_{opt}} + PV\%_o + PG\%_o + PTL_{\mu m}_o + PG_{T_{min}} + PG_{T_{opt}}}{PG_{T_{min}} + PTL_{T_{min}} + PTL_{T_{opt}} + PTL_{T_{max}} + CMT_i} \right)$$

$$Cold\ CTRI = \left( \frac{PV\%_o + PG\%_o + PTL_{\mu m}_o + PG_{T_{min}} + PG_{T_{opt}} + PV\%_i + PG\%_i + PTL_{\mu m}_i + PG_{T_{min}} + PG_{T_{opt}}}{PG_{T_{min}} + PTL_{T_{min}} + PTL_{T_{opt}} + PTL_{T_{max}} + CMT_o} \right)$$

### Classification of cultivars for heat tolerance

Sensitive: CTRI = [(minimum CTRI) - (minimum CTRI + 1.5 stdev)]

Intermediate: CTRI = [(minimum CTRI + 1.5 stdev) - (minimum CTRI + 2.5 stdev)]

Tolerant: CTRI = > (minimum CTRI + 2.5 stdev)

### Classification of cultivars for cold tolerance

Sensitive: CTRI = [(minimum CTRI) - (minimum CTRI + 1.5 stdev)]

Moderately sensitive: CTRI = [(minimum CTRI + 1.0 stdev) - (minimum CTRI + 2.0 stdev)]

Moderately tolerant: CTRI = [(minimum CTRI + 2.0 stdev) - (minimum CTRI + 3.0 stdev)]

Tolerant: CTRI = > (minimum CTRI + 3.0 stdev)

## Results

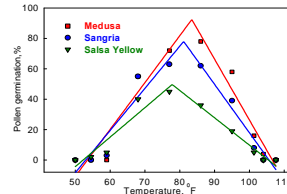


Fig. 1. Temperature response curves of PG

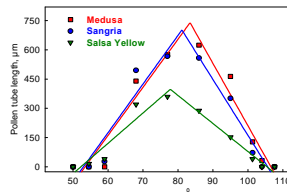


Fig. 2. Temperature response curves of PTL

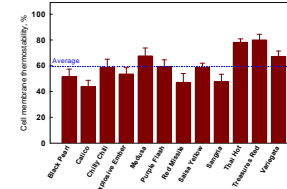


Fig. 3. Variation in cell membrane thermostability

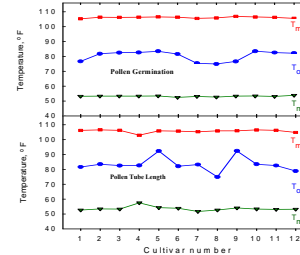


Fig. 4. Variation in cardinal temperatures

### Classification of cultivars based on heat and cold CTRI

Heat-tolerant (CTRI >10.57)	Intermediate (CTRI = 9.74 -10.57)	Heat-sensitive (CTRI < 9.74)	Cold sensitive (CTRI < 9.29)	Moderately cold sensitive (CTRI = 9.29 -10.07)	Moderately cold tolerant (CTRI = 10.07 -10.86)	Cold tolerant (CTRI >10.86)
'Chilly Chili'	'Calico'	'Black Pearl'				
'Medusa'	'Explosive Ember'	'Red Missile'	'Thai Hot'	'Purple Flash'	'Calico'	'Salsa Yellow'
'Treasures Red'	'Purple Flash'	'Salsa Yellow'	'Treasures Red'	'Sangria'		
'Thai Hot'	'Sangria'			'Variegata'		
	'Variegata'			'Explosive Ember'		

## Conclusions

- Cell membrane thermostability and pollen parameters are useful for thermotolerance in ornamental peppers
- The identified heat and cold tolerant cultivars are potential candidates for ornamental pepper breeding programs and in selecting cultivars for a niche environment
- Even though significant correlation exists between cell membrane thermostability and pollen-based parameters ( $r = 0.54^*$ ), screening based on pollen parameters is a more accurate approach for reproductive thermotolerance, particularly for fruit set

### Cold Tolerant Cultivars

'Salsa Yellow'



'Red Missile'



### Moderately Cold Tolerant Cultivars

'Calico'



'Black Pearl'



### Heat Tolerant Cultivars

'Thai Hot'



'Medusa'



'Chilly Chili'



'Treasures Red'

