# Potential Benefits of Using Hydrogen Peroxide in Crop Production Systems

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# Why Hydrogen Peroxide ($H_2O_2$)?

**Crop stress**

- Crop plants subject to various stresses in their life cycle
- Crops develop stress tolerance or lose yield
- Most stresses are related to oxidative stress

**$H_2O_2$**

- Low concentration – a signaling compound
- High concentration – toxic causing cell death

**In this presentation**

- Can exogenous $H_2O_2$ reduce chilling injury?

# Why Chilling Injury?

**Greenhouse vegetables – chilling sensitive**

- Tomatoes
- Cucumbers
- Sweet peppers

**Chilling sensitivity – storage temperature of higher than 10°C is recommended**

**Consequence of chilling injury (< 10°C)**

- Decay

# Chilling Injury – symptoms and cause

**Symptoms of chilling injury**

- Pitting
- Decay
- Other (e.g. reduced radicle elongation)

**Symptoms – most obvious after returning to room temperature**

**Causes – reactive oxygen species (ROS)**

# Objectives – $H_2O_2$ to Reduce Chilling Injury

**Chilling stress**

- Experimental plant – sweet potato
- Greenhouse crop – sweet pepper

**Sweet potato – leaves and shoots (during production)**

- Chilling injury < 10°C

**Sweet peppers – colored fruits (during storage)**

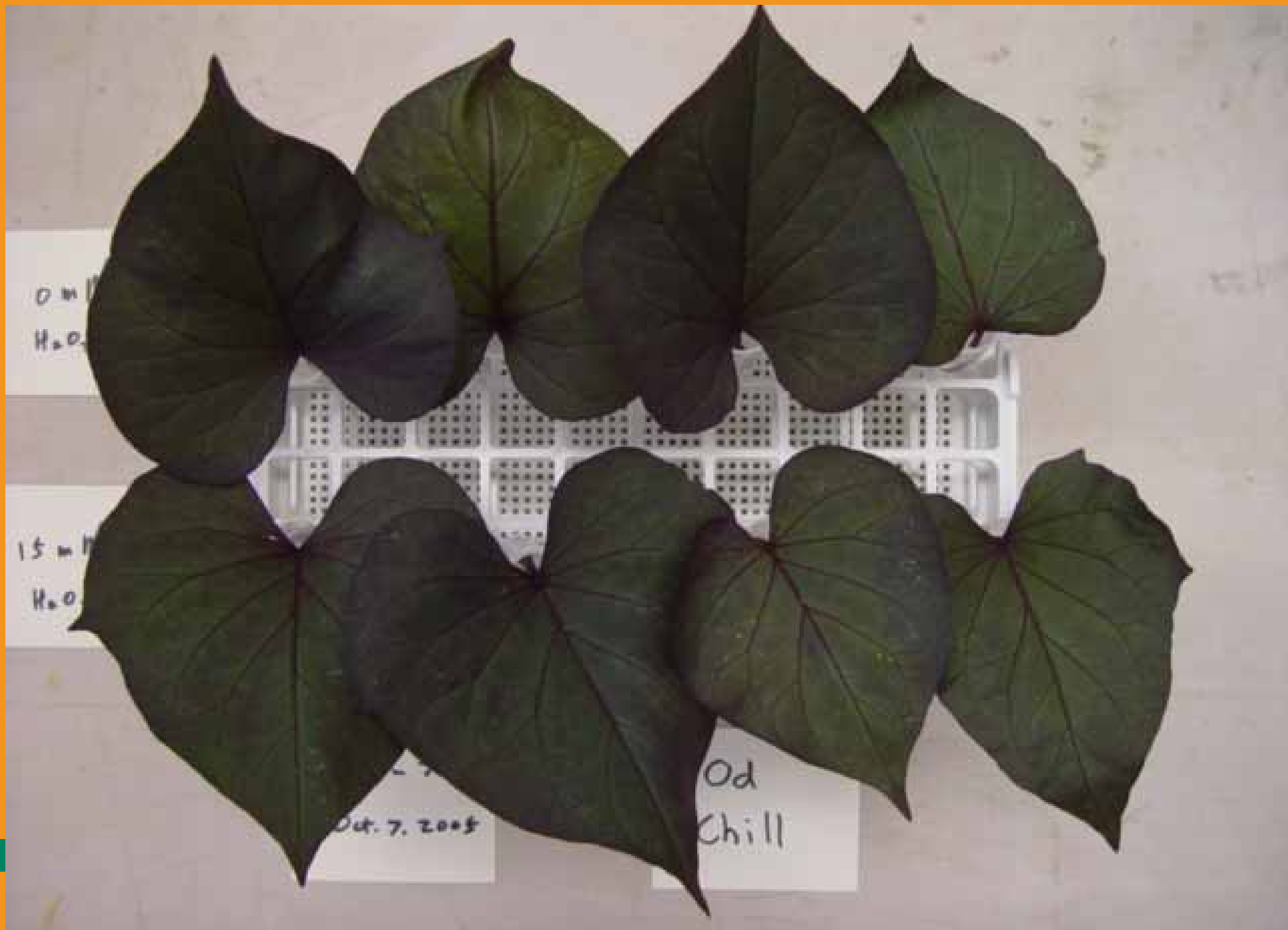
- Chilling injury < 7°C
- Decay, high $CO_2$, high $C_2H_4$
- *Alternaria* rot (< 7°C)
- *Botrytis* decay (< 4.5°C)

**Sweet potato and sweet peppers – used in our study**

# Sweet Potato – Leaf (Injury index of 0 to 5 after days at 2.5°C followed by 3 days at room temperature)

| $H_2O_2$ | Non-chilled | Chilled |
|---|---|---|
| 0 mM | 0.12 | 2.25 |
| 15 mM | 0 | 0.38 |

# Sweet Potato – Leaf (Non-Chilled)



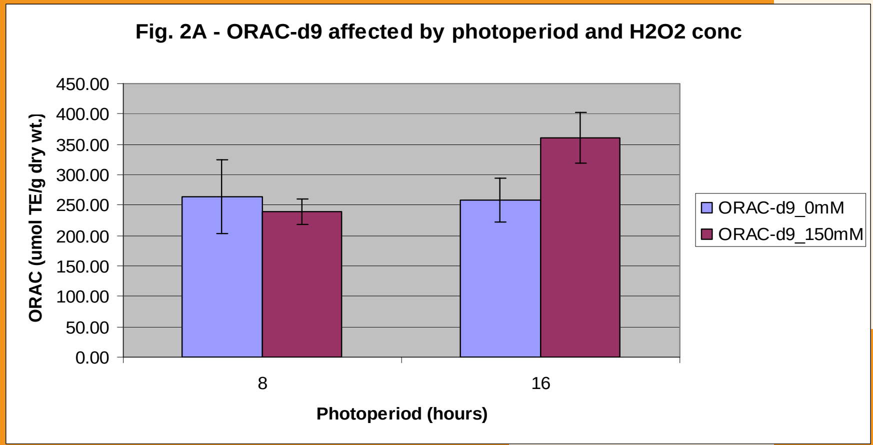
# Sweet Potato – Leaf (Chilled)

# Sweet Potato – Shoot Tip (3-day chill at 2.5°C followed by 2 or 7 days at 20°C)

**150 mM $H_2O_2$ + 16h photoperiod**

**Increased antioxidant capacity (ORAC) of chilled shoot tips**

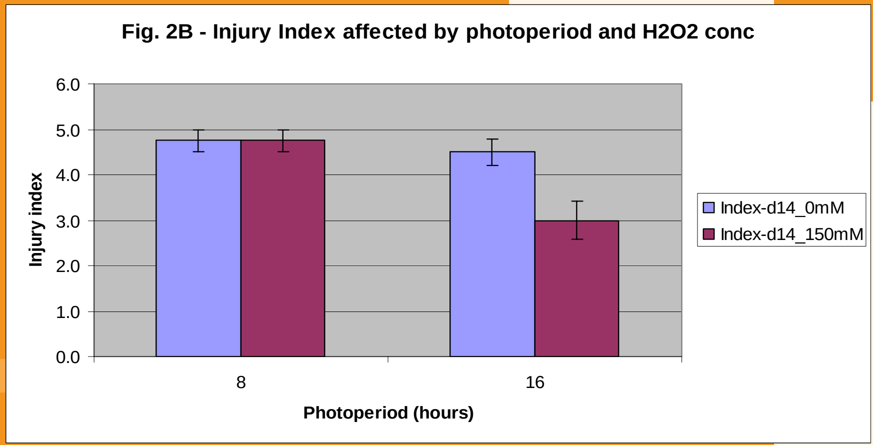
**2 days after chilling**




**150 mM $H_2O_2$ + 16h photoperiod**

**Reduced injury index of chilled shoot tips**

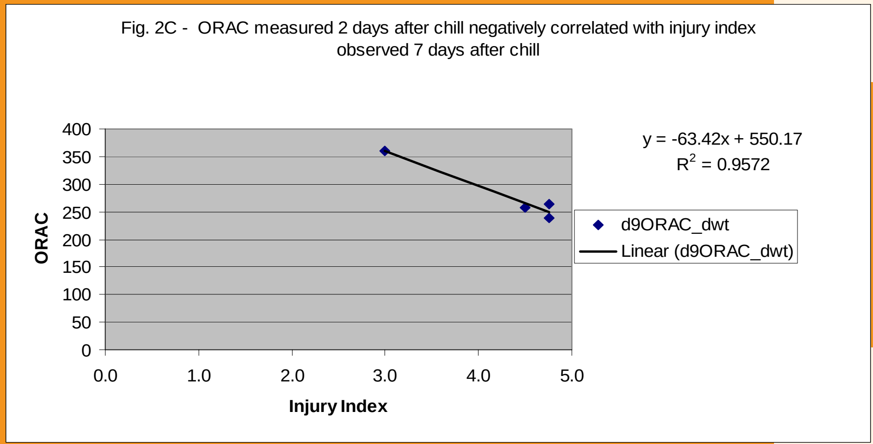
**7 days after chilling**



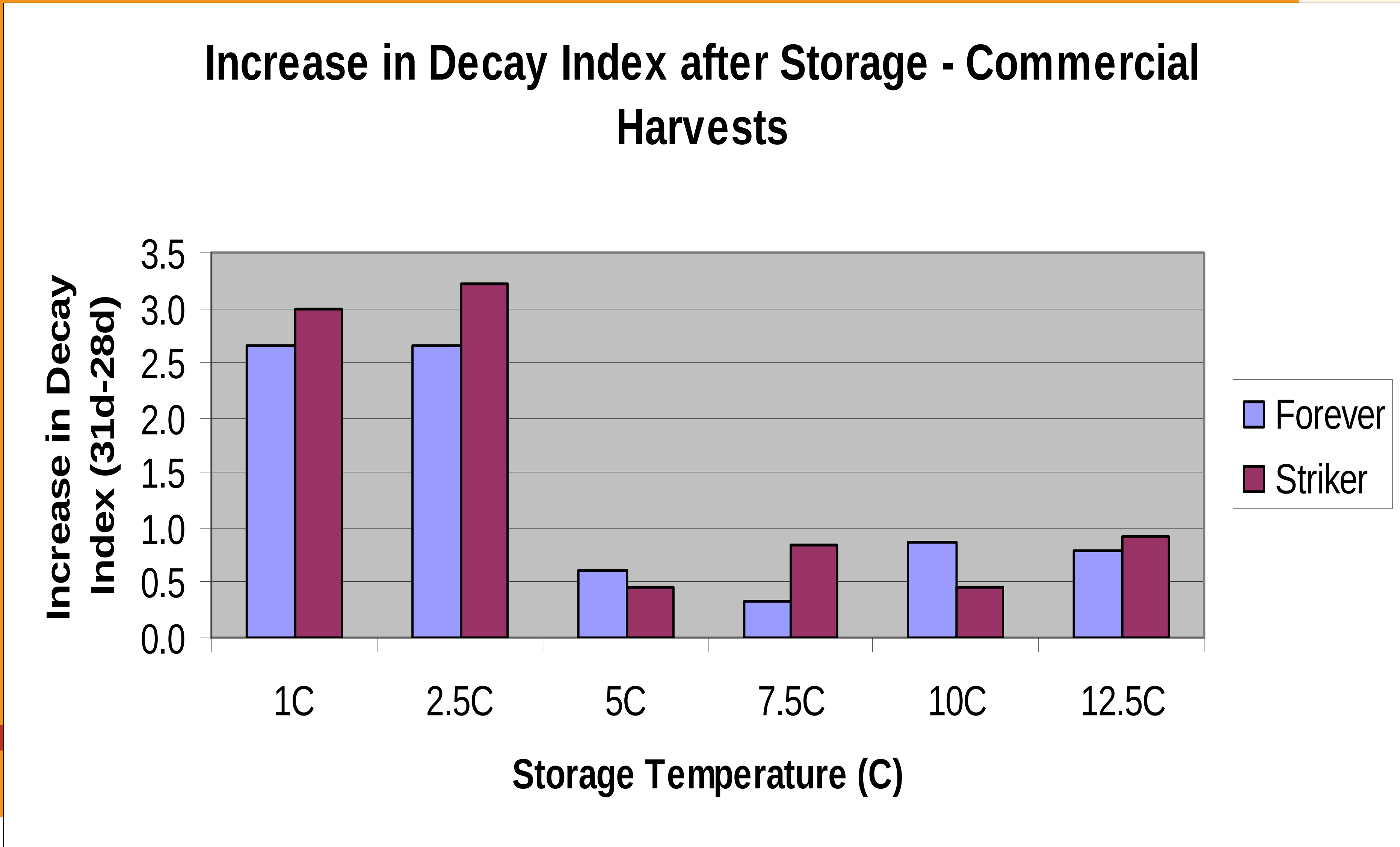
# Sweet Potato – Shoot Tip (3-day chill at 2.5°C followed by 2 or 7 days at 20°C)

**Negative correlation between antioxidant capacity (ORAC) and chilling injury**

**Increase of ORAC preceded the reduction of injury index**



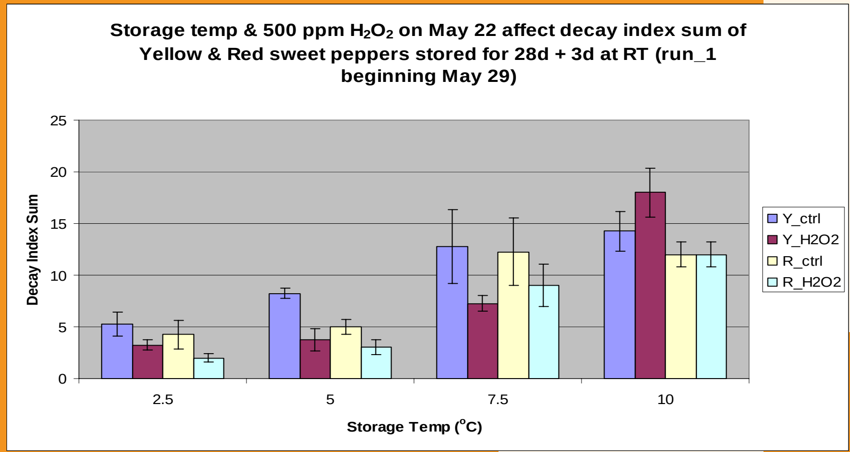
# Sweet Pepper - Commercial Harvests

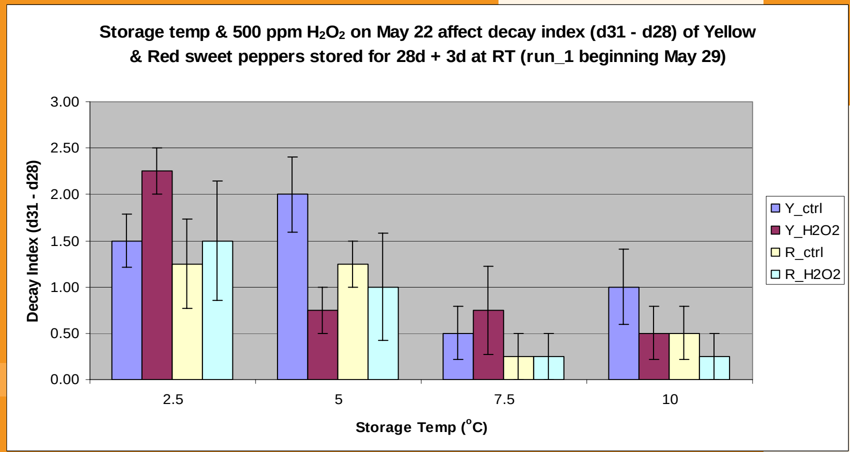


# Effects of pulsed 500 ppm $H_2O_2$ (ca. 14.7 mM) on decay of stored sweet peppers

$H_2O_2$ decreased the decay of stored sweet peppers

At 2.5° or 5°C, chilling injury occurred

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# Sweet Pepper – Fruit (decay index after 4-week storage plus 3 days at room temperature)

| Weeks after pulse $H_2O_2$ application | 2.5°C | 5.0°C | 7.5°C | 10.0°C |
|---|---|---|---|---|
| Week 1 | 4.6 | 6.9 | 13.6 | 21.8 |
| Week 2 | 6.0 | 8.5 | 15.3 | 17.7 |
| Week 3 | 7.5 | 12.7 | 17.4 | 19.9 |

# $H_2O_2$ – Induced Chilling Tolerance

**Survival rate: after a 36h, 4°C chilling stress**

- 8°C pre-treated seedlings – 97 %
- $H_2O_2$ pre-treated seedling – 71%
- Control (25°C) – 33%

**Chilling of mung bean seedlings induces symptoms of oxidative stress. Both acclimation at 8°C and $H_2O_2$ pre-treatment stimulate protective mechanisms that alleviate chilling stress. Glutathione is an essential, but not the only, protective compound.**

**Yu et al,. 2002. $H_2O_2$ treatment induces glutathione accumulation and chilling tolerance in mung bean. Funct. Plant Biol. 29: 1081-1087.**

# $H_2O_2$ – Induced Salt Tolerance

**Barley: 5 – 25 mM $H_2O_2$ induced maximal accumulation of osmoprotectant (e.g. glycinebetaine)**

**Rice: 10 µM $H_2O_2$ enhanced salt tolerance in rice seedlings**

**Tomato: 50 mM $H_2O_2$ increased sugar content in tomato fruit by 1.5 fold**

**Uchida et al. 2006. Induction of biosynthesis of osmoprotectants in higher plants by hydrogen peroxide and its application to agriculture, in A.K. Rai and T. Takabe (eds.), *Abiotic Stress Tolerance in Plants*, 153-159, Springer, The Netherlands.**

# Conclusion – Our Study Indicates

- Sweet Potato – $H_2O_2$ increased chilling tolerance of excised leaves (15 mM $H_2O_2$) and shoot tips (150 mM $H_2O_2$)
- Sweet Pepper – pulsed 500 ppm $H_2O_2$ (14.7 mM) application in greenhouse decreased storage decay at 2.5 or 5°C
- Beneficial effects of $H_2O_2$ appear to vary with environments under which crop plants are grown
- Careful experiments are necessary to define parameters of practical uses of $H_2O_2$ in crop production systems

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