Potential Benefits of Using Hydrogen Peroxide in Crop Production Systems

W. C. Lin and G. S. Block
Agriculture and Agri-Food Canada
Pacific Agri-Food Research Centre
Agassiz, BC, Canada

Agriculture and Agri-Food Canada   Agriculture et Agroalimentaire Canada

Canada

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 3 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)

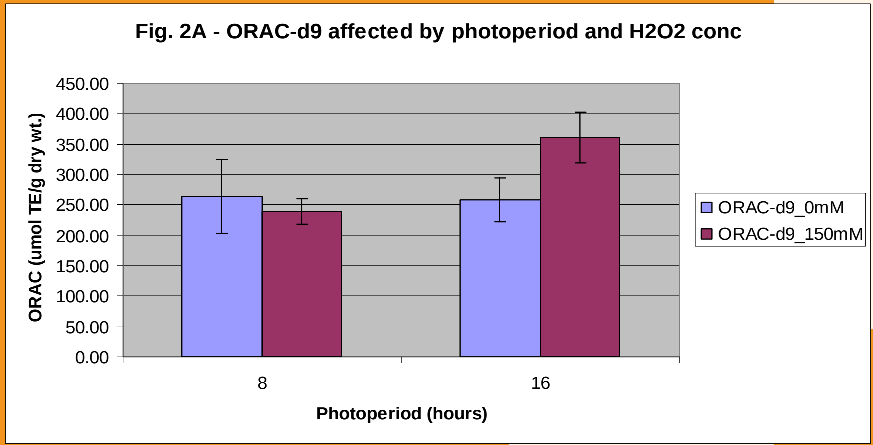
Sweet Potato – Leaf (Chilled)

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

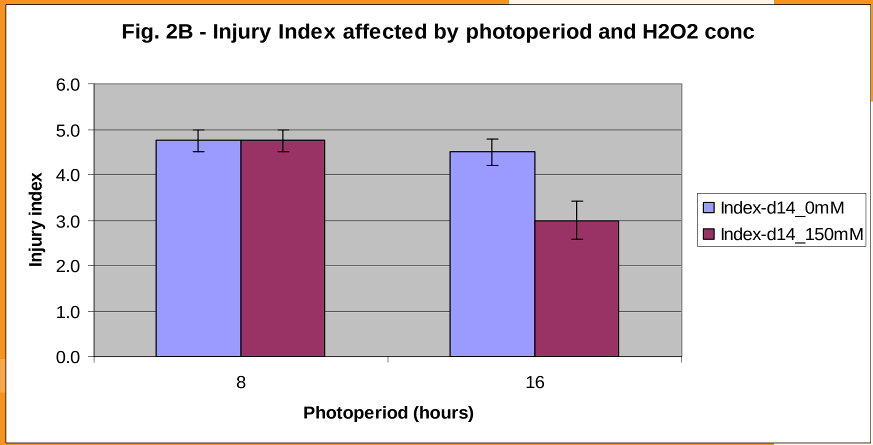
2 days after chilling



150 mM H_2O_2 + 16h photoperiod

Reduced injury index of chilled shoot tips

7 days after chilling

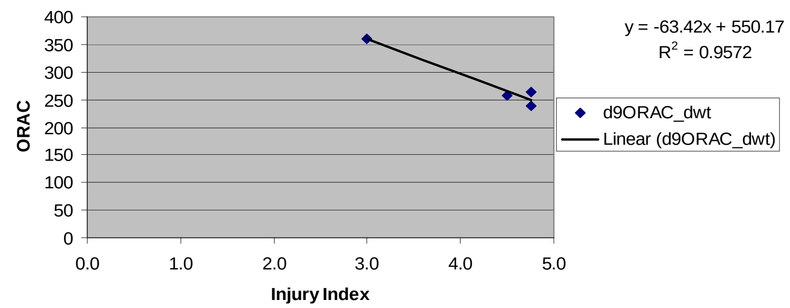


Sweet Potato – Shoot Tip (3-day chill at 2.5°C followed by 2 or 7 days at 20°C)

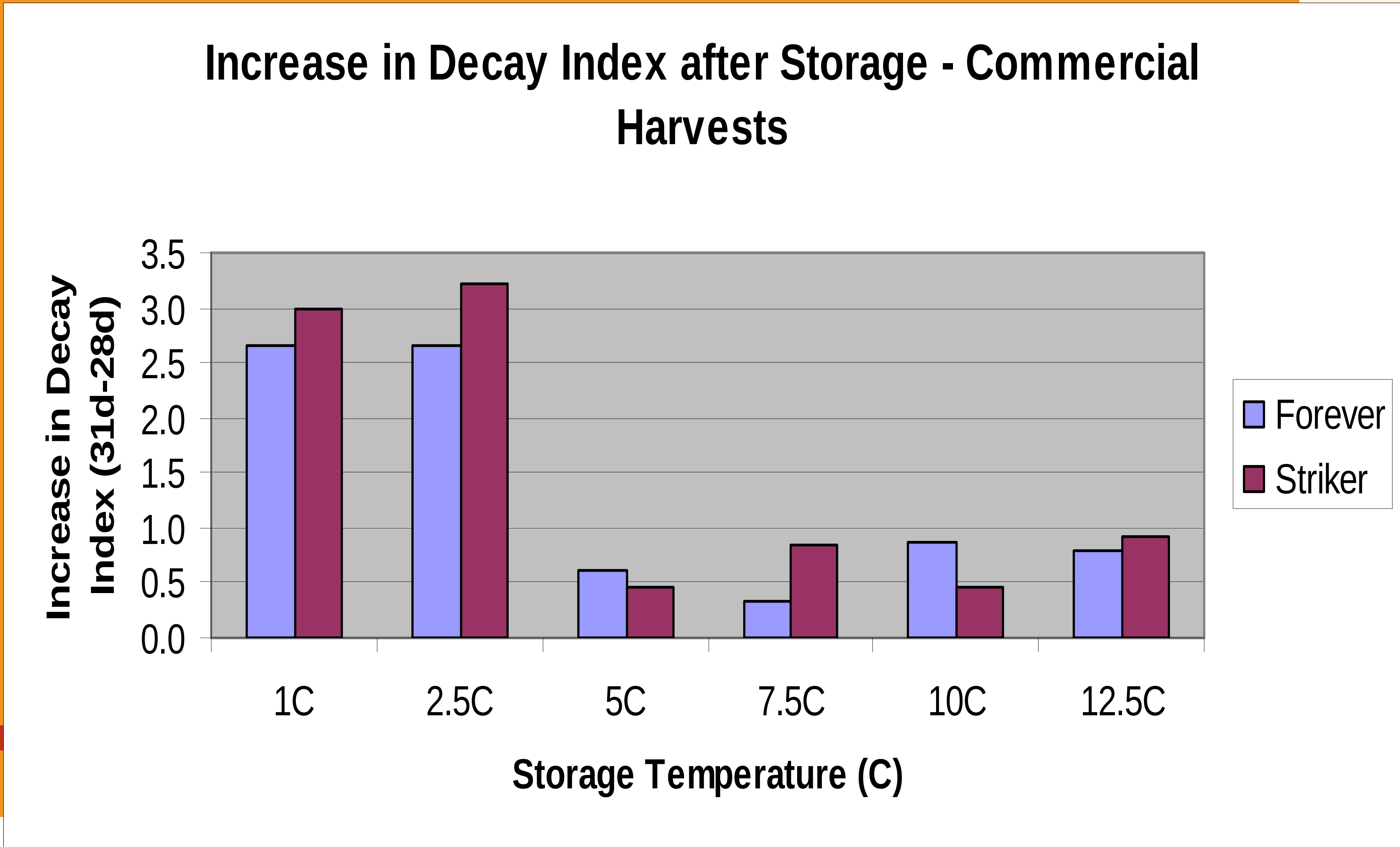
Negative correlation between antioxidant capacity (ORAC) and chilling injury

Increase of ORAC preceded the reduction of injury index

Fig. 2C - ORAC measured 2 days after chill negatively correlated with injury index observed 7 days after chill



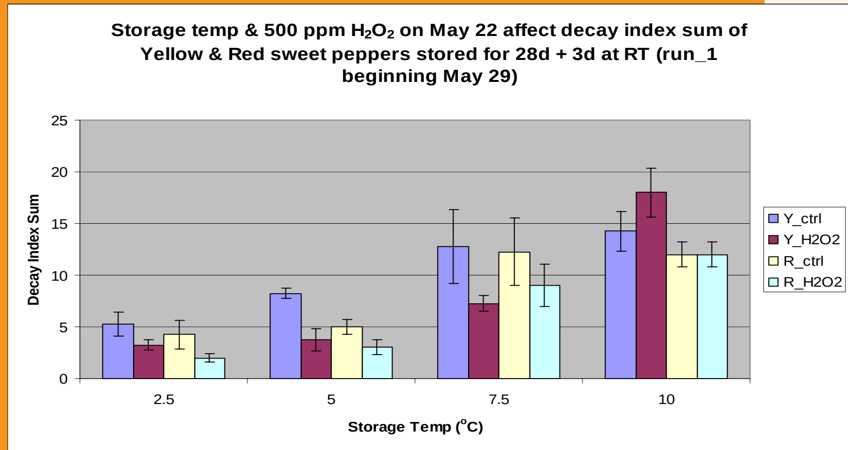
Sweet Pepper - Commercial Harvests

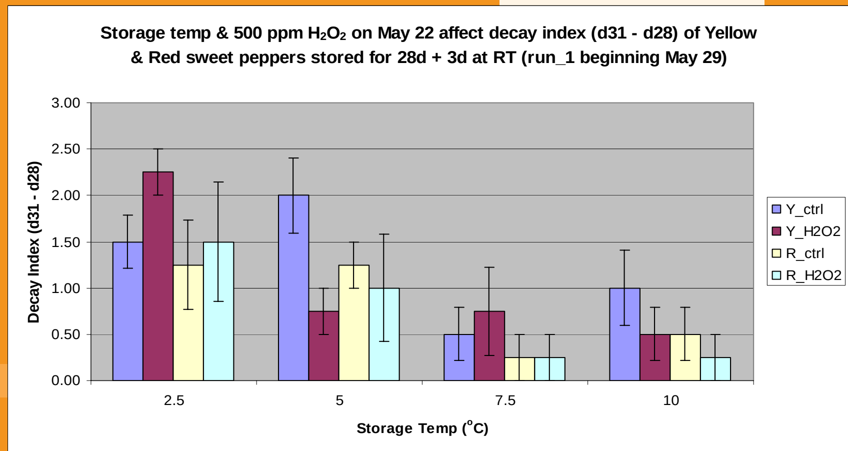


Effects of pulsed 500 ppm H_2O_2 (ca. 14.7 mM) on decay of stored sweet peppers

H_2O_2 decreased the decay of stored sweet peppers

At 2.5° or 5°C, chilling injury occurred





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

Pacific Agri-Food Research Centre, Agassiz, British Columbia, Canada

Agriculture and Agri-Food Canada

Agriculture et Agroalimentaire Canada

Canada