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# Effect of Treatment of Potatoes in Storage and Pre-Planting with Hydrogen Peroxide ($H_2O_2$) on Emergence and Yield

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**Abstract:** Field trials were conducted in Hartland, New Brunswick, Canada to study the effect of in-storage treatment of seed potatoes with hydrogen peroxide ($H_2O_2$) on emergence and yield parameters of Dark Red Norland potatoes. The trials included: (1) an untreated control; (2) control untreated with $H_2O_2$ in storage but sprayed with a mixture of $H_2O_2$ and water at a rate of 1:100 before planting; (3) potatoes treated with $H_2O_2$ in storage at 1:50 rate for 16 weeks and (4) potatoes treated with $H_2O_2$ in storage at 1:50 rate for 16 weeks and then sprayed with $H_2O_2$ at 1:100 rate prior to planting. Plant emergence was assessed and percent emergence was calculated 45 days after planting. Potato tubers were graded for total yield, tuber size, tuber weight, tuber number and miss-shaped tubers. Tuber sizes included the following categories: <1.75", >1.75"≤2.0", >2.0"≤2.25", >2.25"≤2.75", >2.75"≤3.0", >3.0"≤3.25" and >280 g. Marketable yield which included all tubers measuring >2" in diameter was also calculated. Among these treatments, application of $H_2O_2$ in storage and then treating seed pieces before planting with $H_2O_2$ at the rate of 1:100 resulted in significantly higher percentage of seedling emergence and total and marketable yields compared to other treatments. The remaining three treatments did not differ significantly among each other with respect to percent seedling emergence and total and marketable yields. Results of this study indicated that under the conditions followed in these trials, $H_2O_2$ had no negative effect on sprouting, seedling emergence or yield. This is the first study of its kind to examine the effect of storage treatment of potatoes with $H_2O_2$ before planting on yield parameters of potato, including emergence, yield, size and weight of harvested tubers.

**Key words:** Emergence, hydrogen peroxide, marketable yield, oxidate, post-harvest, potato, pre-planting, storage

## INTRODUCTION

Significant post-harvest losses of potatoes (*Solanum tuberosum* L.) are caused by the invasion of fungi, bacteria and other organisms and losses caused by post-harvest diseases of fruits and vegetables are cited to be of severe nature (Snowdon, 1990, 1992; Waller, 2002). Microorganisms attack fresh products easily and spread quickly, as such products lack natural defense and possess a reservoir of nutrients and moisture to support microbial growth. Losses in potato storages are mainly due to decay caused by various pathogens (Meijers, 1987a; Snowdon, 1992; Afek *et al*., 1999). Storage diseases are difficult to control due to the scarcity of registered chemical products for post-harvest use. The prevalence of favorable atmospheric conditions in storages is congenial for the spread of post-harvest potato pathogens.

Generally, fruits and vegetables are prone to infection in the field during crop development. Although growers grade out infected fruits and tubers before storage, some symptoms in their early stages of development go unnoticed. In some cases the infection that does occur in the field is usually latent and the actual development of rot or decay takes place after harvest and during storage period.

Post-harvest rots are more prevalent in fruits and vegetables that are bruised or otherwise damaged than in undamaged products. Bruises and other mechanical damage not only detract from the appearance of the product, but are good avenues of entrance for decay organisms. In storage, humid and warm storage conditions encourage the growth of microbial contaminants. The losses under storage conditions are caused by diseases such as silver scurf, soft rot, dry rot, pink rot and others (Snowdon, 1992; Afek and Warshavsky, 1998; Secor and Gudmestad, 1999; Carnegie *et al*., 2003) and it is necessary to prevent storage losses by use of post-harvest treatments. Curing potatoes before storage is one of the important procedures performed by potato growers in order to protect tubers from disease causing pathogens (Meijers, 1987b). Products such as chlorine dioxide, ozone and hydrogen peroxide have been reported to inhibit the growth of certain storage pathogens (Afek *et al*., 1999, 2001; Olsen *et al*., 2000; Norikane *et al*., 2001; Al-Mughrabi, 2005a, 2006). The use of such products in storage could provide alternative tools that help achieve disease suppression.

Hydrogen peroxide is an environmentally friendly surface disinfestant whose activity is based on oxidation of fungi and bacteria (Aharoni *et al*., 1994; Fallik *et al*., 1994; Afek *et al*., 1999). The product is effective in controlling early blight in potato storage and pink rot and late blight pathogens *in vitro* (Al-Mughrabi, 2005a, b, 2006). The present study examined whether storage treatment of potatoes with $H_2O_2$ before planting has a negative effect on yield parameters of potato, including emergence, yield, size and weight of harvested tubers.

## MATERIALS AND METHODS

### $H_2O_2$ Application in Storage

OxiDate™ (27% hydrogen peroxide; $H_2O_2$), a clear, colorless liquid with a pungent odor (freezing point, -30°C; specific gravity, 1.09; pH, 1.33; solubility, complete) was supplied by BioSafe Systems, CT, U.S.A. and used in this study. Two post-harvest treatments: (1) untreated control and (2) treatment with $H_2O_2$ and water applied at the rate 1:50 (v/v) were applied to seed potato tubers (cv. Dark Red Norland) in storage daily for 2 weeks (8 h $day^{-1}$) and then once (8 h $week^{-1}$) for 14 weeks. Each treatment was carried out in a separate storage bin to prevent cross contamination. Bins were set at approximately 50°F and 90+% RH. The control treatment was treated with sterile distilled water. All treatments were applied using a fogging system connected to a 5 hp air compressor (Al-Mughrabi, 2005a). Airflow (1.25 CFM/100 cwt) was turned on at the same time as the fogging system to allow the fog to spread through the tubers. The fogging system consisted of a 14-gallon water tank, timer, fogging controller and air and water solenoids mounted on a free standing wooden support frame. Air and water hoses were placed under a 1 ft high pallet next to the plenum. The fogging system was calibrated to emit an amount of 4-gal/8 h. The storage trials were conducted in 2003 in Wicklow, New Brunswick, Canada.

### Seed Preparation and Treatment

Storage-treated potato seed pieces (control and 1:50 $H_2O_2$) weighing 50-65 g each were exposed to one of four treatments: (1) untreated control; (2) control untreated with $H_2O_2$ in storage and sprayed with $H_2O_2$ at 1:100 rate before planting; (3) $H_2O_2$ treated potatoes in storage at 1:50 rate for 16 weeks and (4) $H_2O_2$ treated potatoes in storage at 1:50 rate for 16 weeks and sprayed with $H_2O_2$ at 1:100 rate prior to planting.

### Experimental Setup

The experiments were designed as one-way completely randomized block with four treatments that were replicated four times. Each replicate consisted of 25 ft long row and the seed pieces were planted with a spacing of 10". The distance between the rows was maintained at 3 ft. Agricultural

practices commonly performed by potato growers in New Brunswick were followed throughout the growing season (Bernard *et al*., 1993). The field trials were conducted in 2004 in Hartland, New Brunswick, Canada.

**Data Collection and Analysis**

Plant emergence was assessed and percent emergence was calculated 45 days after planting. Potatoes were graded for total yield, tuber size, tuber weight, tuber number and miss-shaped tubers. Tuber sizes included the following categories: <1.75", >1.75"≤2.0", >2.0"≤2.25", >2.25"≤2.75", >2.75"≤3.0", >3.0"≤3.25" and >280 g. Marketable yield which included all tubers measuring >2" in diameter, was also calculated. Potato tubers <2" in diameter and miss-shaped were excluded when marketable yield was calculated. Data were statistically analyzed using CoStat (CoHort Software, Monterey, CA, USA) and the means were separated using LSD test at p = 0.05. All data were pooled and presented.

## RESULTS AND DISCUSSION

**Effect of $H_2O_2$ Treatment on Emergence**

The effects of treatments on seedling emergence were variable. Seed treated with $H_2O_2$ in storage for 16 weeks at 1:50 rate and sprayed with $H_2O_2$ at 1:100 rate before planting was significantly different from all other treatments and recorded the highest percent seedling emergence (84.17%). The other three treatments did not differ significantly at p = 0.05 (Table 1). The effect of $H_2O_2$ on seedling emergence was higher when it was used both during storage and before planting. Hydrogen peroxide aided in protecting seed tubers from seed- and soil-borne pathogens and consequently improved emergence. The role of hydrogen peroxide in plant disease response in the form of having antimicrobial effect (Wu *et al*., 1995), structural changes in the plant's cell wall (Dean and Kuc, 1987; Brisson *et al*., 1994), production of toxic, lipid free radicals (Keppler and Baker, 1989) and activation of phytoalexin synthesis (Chai and Doke, 1987; Apostol *et al*., 1989) are reported earlier.

**Effect of $H_2O_2$ Treatment on Total and Marketable Yield**

Tubers treated with $H_2O_2$ both in storage and at planting recorded significantly higher total tuber yield (219 cwt/acre) compared to the other three treatments (Tabe 1). Treatment of seed tubers with $H_2O_2$ in storage for 16 weeks at 1:50 rate and spraying with $H_2O_2$ at 1:100 rate before planting was significantly different from all other treatments resulting in highest marketable tuber yield of 202 cwt/acre. The other three treatments did not differ significantly from each other at p = 0.05 (Table 1). Application of $H_2O_2$ resulted in higher emergence and higher plant stand, which played a role in the increased tuber yield. The higher tuber yields are due to the reduction in inoculum's level on the seed and also seed tubers protection against soil-borne pathogens. In studies reported by Afek *et al*. (1999) where $H_2O_2$ was applied in storage using a fogging system, potato decay was 4% compared to 26% in non-treated control. Other studies indicated that $H_2O_2$ applications reduced or inhibited potato diseases in storage and potato pathogens *in-vitro* (Afek *et al*., 1999, 2001; Olsen *et al*., 2000; Norikane *et al*., 2001; Al-Mughrabi, 2005a, b, 2006).

**Effect of $H_2O_2$ Treatment on Tuber Size and Knobby Tubers**

The treatments had significant effect on the number of tubers of different sizes except for tubers sized >2.75"≤3.0", >3.0"≤3.25" and 280 g (Table 2). The number of tubers was higher in the treatment with $H_2O_2$ both in storage and before planting and was significantly superior to other treatments (Table 2). Tubers of different sizes did not differ significantly among treatments with regard to weight of tubers excluding tubers of >1.75"≤2.0" and >2.25"≤2.75" size (Table 3). Seed treatments with $H_2O_2$

Table 1: Effect of $H_2O_2$ treatments on potato seedling emergence, total yield and marketable yield

| Treatments[1] | Seedling emergence (%) | Total yield (cwt acre$^{-1}$) | Marketable yield (cwt acre$^{-1}$) |
|---|---|---|---|
| C | 57$^{b2}$ | 155$^{bc}$ | 141$^{b}$ |
| OP | 59$^{b}$ | 172$^{bc}$ | 157$^{b}$ |
| OS | 51$^{b}$ | 119$^{c}$ | 109$^{b}$ |
| OS + OP | 84$^{a}$ | 219$^{a}$ | 202$^{a}$ |
| LSD 0.05% | 13 | 44 | 40 |

[1]C = Untreated control; OP = No $H_2O_2$ in storage + seed treatment with $H_2O_2$ at planting (1:100 rate of $H_2O_2$ to water v/v); OS = Seeds treated with $H_2O_2$ in storage (1:50 rate); OS + OP = Seeds treated with $H_2O_2$ in storage (1:50 rate) and at planting (1:100 rate). [2]Each value is the mean of four replicates. Within each column, means followed by same letter(s) are not significantly different from each other at p = 0.05

Table 2: Effect of $H_2O_2$ treatments on number of tubers produced

| | Tuber size (in inches) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments[1] | <1.75" | >1.75 ≤2" | >2 ≤2.25" | >2.25 ≤2.75" | >2.75 ≤3" | >3 ≤3.25" | >280 g | Knobby tubers |
| C | 63$^{a2}$ | 41$^{a}$ | 44$^{a}$ | 56$^{a}$ | 6$^{a}$ | 3$^{a}$ | 1$^{a}$ | 4$^{a}$ |
| OP | 54$^{ab}$ | 23$^{b}$ | 28$^{ab}$ | 44$^{b}$ | 5$^{a}$ | 2$^{a}$ | 1$^{a}$ | 3$^{a}$ |
| OS | 48$^{ab}$ | 18$^{b}$ | 25$^{ab}$ | 32$^{b}$ | 5$^{a}$ | 2$^{a}$ | 1$^{a}$ | 3$^{a}$ |
| OS + OP | 34$^{a}$ | 17$^{b}$ | 21$^{b}$ | 31$^{b}$ | 3$^{a}$ | 1$^{a}$ | 0$^{a}$ | 2$^{a}$ |
| LSD 0.05% | 20 | 12 | 16 | 10 | 5 | 3 | 1 | 3 |

[1]C = Untreated control; OP = No $H_2O_2$ in storage + seed treatment with $H_2O_2$ at planting (1:100 rate of $H_2O_2$ to water v/v); OS = Seeds treated with $H_2O_2$ in storage (1:50 rate); OS + OP = Seeds treated with $H_2O_2$ in storage (1:50 rate) and at planting (1:100 rate). [2]Each value is the mean of four replicates. Within each column, means followed by same letter(s) are not significantly different from each other at p = 0.05

Table 3: Effect of $H_2O_2$ treatments on weight (g) of tubers produced

| | Tuber size (in inches) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments[1] | < 1.75" | >1.75 ≤2" | >2 ≤2.25" | >2.25 ≤2.75" | >2.75 ≤3" | >3 ≤3.25" | >280g | Knobby tubers |
| C | 1312$^{a2}$ | 2595$^{a}$ | 4183$^{a}$ | 7921$^{a}$ | 1110$^{a}$ | 725$^{a}$ | 316$^{a}$ | 634$^{a}$ |
| OP | 1174$^{a}$ | 1464$^{b}$ | 3312$^{a}$ | 6441$^{a}$ | 1075$^{a}$ | 606$^{a}$ | 225$^{a}$ | 413$^{a}$ |
| OS | 1102$^{a}$ | 1145$^{b}$ | 2668$^{a}$ | 4713$^{b}$ | 976$^{a}$ | 519$^{a}$ | 153$^{a}$ | 404$^{a}$ |
| OS + OP | 741$^{a}$ | 1047$^{b}$ | 2052$^{a}$ | 4462$^{b}$ | 451$^{a}$ | 119$^{a}$ | 0$^{a}$ | 210$^{a}$ |
| LSD 0.05% | 547 | 768 | 1705 | 1549 | 1031 | 694 | 409 | 463 |

[1]C = Untreated control; OP = No $H_2O_2$ in storage + seed treatment with $H_2O_2$ at planting (1:100 rate of $H_2O_2$ to water v/v); OS = Seeds treated with $H_2O_2$ in storage (1:50 rate); OS + OP = Seeds treated with $H_2O_2$ in storage (1:50 rate) and at planting (1:100 rate). [2]Each value is the mean of four replicates. Within each column, means followed by same letter(s) are not significantly different from each other at p = 0.05

were significantly superior to other treatments with respect to tuber weight. None of the treatments had a significant effect on the weight of knobby tubers (Table 3). The weight of knobby tubers was higher in the untreated control treatment while the number and weight of knobby tubers were less in the treatments that received $H_2O_2$ (Table 2 and 3). The treatments which involved applications of $H_2O_2$ reduced the number and weight of knobby tubers compared to untreated control.

This study indicated that treatment of seed potatoes with $H_2O_2$ during storage and again before planting proved to be very effective in improving seedling emergence and resulted in higher total and marketable yields. The treatment with $H_2O_2$ recorded less number and weight of knobby tubers compared to control and indirectly was able to produce larger number of tubers. The higher yields were obtained due to the suppression of potato pathogens on or around the seed tubers at planting. This is the first study of its kind that involves the application of $H_2O_2$ during 'potato' storage and prior to planting and its effect on emergence and yield parameters. The results of the current study suggest that using $H_2O_2$ in a proper manner did not inhibit sprouting or germination.

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