STORAGE MANAGEMENT OPTIONS FOR DISEASE CONTROL

Nora Olsen and Jeff Miller
Potato Specialist and Potato Pathologist
Dept. of Plant, Soil and Entomological Sciences
University of Idaho
Twin Falls, ID 83303 and Aberdeen, ID 83210

Despite every grower's best effort to grow and harvest a healthy and sound potato crop, there are several diseases that can cause mild to severe crop losses once the potatoes are in storage. Diseases that are of concern in storage include silver scurf (caused by *Helminthosporium solani*), Fusarium dry rot (caused primarily by *Fusarium sambucinum*), late blight (caused by *Phytophthora infestans*), early blight (caused by *Alternaria solani* and *A. alternata*), pink rot (caused by *Phytophthora erythroseptica*), Pythium leak (caused by various *Pythium* spp.), and soft rot (caused by *Erwinia carotovora*). Soft rot can often be the most damaging of these diseases. Tubers with many of these diseases are more susceptible to secondary soft rot development and often create "hot spots" which can lead to the entire breakdown of potatoes in storage.

The three basic tools of storage management, temperature, humidity, and airflow, will help in managing many of these diseases in storage. There are also post-harvest applied products available or in development that aid in the control and suppression of storage diseases. The two major product categories available are fungicides and general biocides or disinfestants. If post-harvest products are employed, they must be used in combination with good basic storage management.

Storage Management: The wound healing or curing period is an important time to properly heal cuts and bruises, reduce disease spread, and reduce shrinkage. Wound healing and curing typically occurs at 50-55°F over 2-3 weeks. The warmer temperatures will promote faster breakdown of water rots, therefore curing temperatures may need to be at 50°F. Time at lower curing temperatures may need to be lengthened to obtain adequate wound healing. Lower holding temperatures typically decrease the rate of disease infection and can be used to your advantage. Both ramping rate and holding temperature will be dictated by the end-use of the potato particularly if it will be processed. It is important to balance the need for disease management and maintaining french-fry quality. With other end-uses, decrease the temperature as quickly as allowable. Depending upon the percentage of rot in the storage, the pile may need additional drying through reductions in humidity, but realize additional shrinkage will result. A lack of humidification will also delay wound healing. Continuous fan operation and high airflow are necessary to dry out wet or problem potatoes, thus reducing the likelihood for further disease development. Simply exposing the soft rot pathogen on the surface of a potato to air for 1 hour will reduce the pathogen viability by 90%.

Post-harvest Products: Typically post-harvest products are applied as a low-pressure spray as potatoes are being conveyed into storage. Some post-harvest disinfestants are applied through the humidification system during the storage season. Post-harvest fungicides are specific to a particular organism or class of organisms whereas disinfestants are general biocides with a wide spectrum against both bacteria and fungi.

Fungicides. Mertect™ (thiabendazole) and Dithane™ (mancozeb) are traditional fungicides that have been used post-harvest to manage Fusarium dry rot. Dithane can only be used on seed tubers not for human or feed consumption. However, efficacy of Mertect has declined due to widespread fungicide resistance in both dry rot and silver scurf fungi. Two newer post-harvest products are Biox C (clove oil) for control of silver scurf and Bio-Save 10 LP (the bacterium *Pseudomonas syringae*) for control of Fusarium dry rot and silver scurf. Although research has shown some efficacy with these two products, disease reduction has not been substantial and may not warrant the cost of application. Recent research has shown some promising results with products that have not yet been registered, such as azoxystrobin (Quadris™) at low rates, as a post-harvest application for the suppression of silver scurf in storage.

A recently registered fungicide, considered a biofungicide, is phosphorous acid (Phostrol™; Fosphite™) which is applied as a spray going into storage for control of pink rot and late blight in storage. University of Idaho initiated this novel idea of a post-harvest application of phosphorous acid products to potatoes with extremely successful results. Numerous studies of ours have evaluated phosphorous acid, primarily Phostrol™, where tubers were inoculated with zoospores of the late blight and pink rot pathogens, and then treated with various products simulating a low-volume (0.5 gallon/ton tubers) post-harvest spray. In one of our small storage studies Phostrol™ and hydrogen peroxide/peroxyacetic acid (HPPA; Oxidate™) were applied immediately after inoculation. Phostrol™ was very effective at concentrations as low as 3.2 fl. oz. per ton in reducing both the incidence and severity of late blight and pink rot in storage (Table 1). An HPPA application was somewhat effective on late blight control compared to the control, but did not help in suppressing pink rot disease development. Large scale studies of 2,000 lbs of potatoes for each disease were stored for 3 months at 48°F and showed similar results as the small scale studies (Table 2). In this case, applications were made one hour after tubers were exposed to the pathogen. There was a complete control of late blight and pink rot disease in tubers treated with 12.8 fl.oz/ton of Phostrol™. Even the lower rates of Phostrol™ were effective at suppressing disease development. There was no significant difference between the untreated control and an application of HPPA. Post-harvest applications of phosphorous acids can be an effective tool or management option for pink rot and late blight control in storage. It is still unknown the effectiveness of these products on other potato pathogens.

Table 1. Efficacy of phosphorous acid (Phostrol™) and hydrogen peroxide/peroxyacetic acid (HPPA; Oxidate™) on late blight and pink rot incidence and severity.

	Late Blight		Pink Rot	
Treatment (rate/ton tubers)	Incidence*	Severity	Incidence	Severity
UTC	71.7 a	51.9 a	98.3 a	98.6 a
HPPA (1:50 dilution)	48.3 b	33.5 b	91.7 a	95.5 a
Phostrol™ (1:20 dilution, 3.2 fl. oz.)	3.3 c	3.8 c	0 b	0.0 b
Phostrol™ (1:10 dilution, 6.4 fl. oz.)	3.3 c	4.4 c	0 b	0.0 b
Phostrol™ (1:5 dilution, 12.8 fl. oz.)	0.0 c	0.0 c	0 b	0.0 b

*Values in the same column followed by the same letters are not significantly different at p=0.05.

Table 2. Effect of post harvest applications of phosphorous acid (Phostrol™) and hydrogen peroxide/peroxyacetic acid (HPPA; Oxidate™) on potato tuber rot after three months in storage.[1]

Treatment	Rate/ton tubers	*Late blight**	*Pink rot*
Untreated control		90 a	61 a
HPPA	1:25 dilution	84 a	73 a
Phostrol™	1.6 fl oz (1:40 dilution)	26 b	32 b
Phostrol™	3.2 fl oz (1:20 dilution)	14 bc	10 b
Phostrol™	12.8 fl oz (1:5 dilution)	0 c	0 c

[1] Tubers with typical disease symptoms or showing symptoms of secondary soft rot were counted as rotted tubers.
*Values in the same column followed by the same letters are not significantly different at p=0.05.

Another newer, non-registered fungicide, Zoxamide, also is highly effective against pink rot and late blight but only if applied relatively soon after inoculation occurs. A study that looked at the interval between inoculation and treatment showed that HPPA needed to be applied within 4 hours of inoculation for a 30% reduction in late blight (Table 3) and applied immediately for a 45% reduction in pink rot (data not shown). Comparatively, Zoxamide applications were more effective at longer post-inoculation intervals, whereas Phostrol™ applications showed excellent control for both pink rot and late blight even 6 hours after inoculation. These studies stress the importance in timing of inoculation and application, may explain inconsistencies in conflicting testimonials, and the long-term or "reach back" potential of Phostrol™.

Table 3. Effect of post-inoculation interval on post-harvest treatment for incidence of late blight on Russet Burbank tubers.

Treatment	Post inoculation interval (hours)				
(rate/ton tubers)	0	1	2	4	6
Untreated control	80.0 a	73.3 a	76.7 a	93.3 a	80.0 a
HPPA (1:50 dilution)	10.0 b	33.3 b	40.0 b	63.3 b	71.7 a
Zoxamide (1.28 oz)	0.0 c	8.3 c	18.3 c	30.0 c	43.3 c
Phostrol™ (1:5 dilution)	0.0 c	0.0 c	1.7 d	0.0 d	6.7 d

*Values in the same column followed by the same letters are not significantly different at p=0.05.

<u>Disinfestants.</u> The use of general biocides has increased substantially in recent years. Examples include hydrogen peroxide/peroxyacetic acid mixtures (HPPA, e.g. Oxidate™, Tsunami™), chlorine dioxide (e.g. Anthium™, Purogene™), and ozone. HPPA has shown varying results depending upon application timing and disease presence (see Tables 1, 2, and 3). Chlorine dioxide (ClO_2) is an effective general biocide for other industries such as water purification, and has been effective at low concentrations against potato disease organisms in the laboratory. Inconsistent performance of ClO_2 in storage appeared to be a result of several contributing factors. Chlorine dioxide concentrations varied greatly (up to 6 fold), depending upon the method of activating and diluting sodium chlorite solutions. Chlorine dioxide is a gas soluble in water and, therefore, is easily released from solution (25-75% loss) into the air when applied as an aqueous spray. Chlorine dioxide reacts quickly with the tuber and associated organic matter, thereby reducing the effectiveness.

In general, there are post-harvest product options available that may be effective for your potato program, but they must be used in combination with good, basic storage management strategies.