

# POTATO HARVEST MANAGEMENT

William H. Bohl

What is generally termed harvest management is primarily aimed at minimizing tuber damage so could essentially be called bruise management. Bruised tubers may result in increased shrinkage in storage, more disease, loss of product, less consumer appeal, and lower prices to the producer. Although most tuber damage occurs during harvest, not all management practices pertaining to minimizing bruise damage is confined to the harvest period. This article will discuss management practices focused on minimizing bruise damage.

## **TYPES OF BRUISES**

**Blackspot Bruise:** An impact does not break the skin of a tuber, but damages several cell layers beneath the skin causing a chemical reaction within the cells to form a dark gray to black pigment called melanin. The reaction takes 24 to 48 hours to complete, and the damage cannot be seen unless the tuber skin is removed. Varieties differ in their susceptibility to this damage. For example, Russet Burbank is susceptible whereas Ranger Russet is very susceptible and Russet Norkotah is only moderately susceptible.

**Shatter Bruise:** The tuber skin and possibly several layers of cells underneath the skin are cracked or broken by an impact. The cracks may become more visible upon drying.

**Skinning:** This damage is not caused by an impact, but rough handling of tubers with immature skins may cause the skin to be scuffed off exposing the tuber flesh. Exposed flesh turns dark when subjected to the open environment.

**Pressure Bruise:** This damage is not directly associated with harvest, but potatoes that were dehydrated at harvest or become dehydrated in storage will, after several months in storage, become flattened and the area beneath the skin discolors as a result of cell damage.

## **MANAGEMENT BEFORE HARVEST**

**Field Selection and Tillage:** Not all fields may be equally suited for potato production. Fields with excessive rocks or those that easily form clods are less suited for minimizing potato bruise damage. Avoid working wet fields with high clay content (heavy soils) in the spring to avoid clod formation because these clods will usually not break apart during the growing season. Fall tillage of fields with heavy soil is a better practice because this allows time for clods that form to break apart during the winter.

Planting: Tuber maturity has a role in bruise susceptibility, particularly skinning. Consequently, timely planting will enable the crop to mature before harvest. Ideally, soil temperature at seed piece planting depth should be 48°F or warmer—plants emerge faster in warm soil.

Fertilizer Management: It is difficult to clearly correlate the effects of plant nutrition to bruise susceptibility. However, mineral nutrition appears to have some effect. One of these effects is on skin set, which relates to skinning. Potato fields that have excessive nitrogen and low phosphorus will generally have tubers with immature skins that will easily be damaged during harvest. Potato petiole nitrate-nitrogen levels should drop to 15,000 ppm or lower by mid-August.

Plant nutrition also plays a role in specific gravity. It has been reported that tubers with higher specific gravity are more susceptible to blackspot bruise. A survey of Idaho potato fields showed that Russet Burbank potato tubers had a higher potential to blackspot bruise damage as the specific gravity increased (Table 1).

**Table 1.** Specific gravity of Russet Burbank potatoes in Idaho as it relates to blackspot bruise potential.<sup>1</sup>

<b>Blackspot Severity Group<sup>2</sup></b>	<b>Specific Gravity<sup>3</sup></b>
Resistant (<2.5)	1.074
Mod. Susceptible (2.5 – 3.0)	1.077
Susceptible (3.1 – 3.5)	1.081
Very Susceptible (>3.5)	1.083

<sup>1</sup> Corsini, et al. 1999.

<sup>2</sup> Abrasive peel test ratings where 0=no blackspot and 5=most damage.

<sup>3</sup> Average for all fields in the survey within a blackspot severity group.

Research has been conducted on the effects of potassium on blackspot bruise, but there does not appear to be any consistent outcome. There is some consensus that low potassium in the crop may result in a higher blackspot bruise potential in susceptible varieties. However, under normal potato production practices, using recommended potassium fertilizer amounts should be adequate, and adding more potassium will have little effect on reducing blackspot bruise potential.

Vine Management: Timing of vine kill can have an effect on potential blackspot tuber bruising according to surveys of potato fields in Idaho by Corsini et al. (1999). They found that for Russet Burbank fields there was a significant correlation between vine maturity in late August and blackspot bruise potential. Fields with more mature vines in late August had a higher potential for blackspot bruise than fields with more green vines (Table 2). This same relationship between vine maturity and blackspot bruise potential was found for Ranger Russet fields. Keep in mind, however, that vine maturity is only one part of a total bruise management program that needs to be implemented. Nevertheless, part of managing blackspot bruise for Russet Burbank is to kill the vines before about 40 percent have died naturally, and kill Ranger Russet vines when only about 5 percent of the vines have naturally died to reduce blackspot bruise potential.

**Table 2.** Vine maturity of Russet Burbank potato fields in Idaho as it relates to blackspot bruise potential.<sup>1</sup>

Blackspot Severity Group <sup>2</sup>	Vine Maturity <sup>3,4</sup>		
	1993	1994	Mean
Resistant (<2.5)	17	54	36
Mod. Susceptible (2.5 – 3.0)	33	59	46
Susceptible (3.1 – 3.5)	48	61	55
Very Susceptible (>3.5)	59	89	74

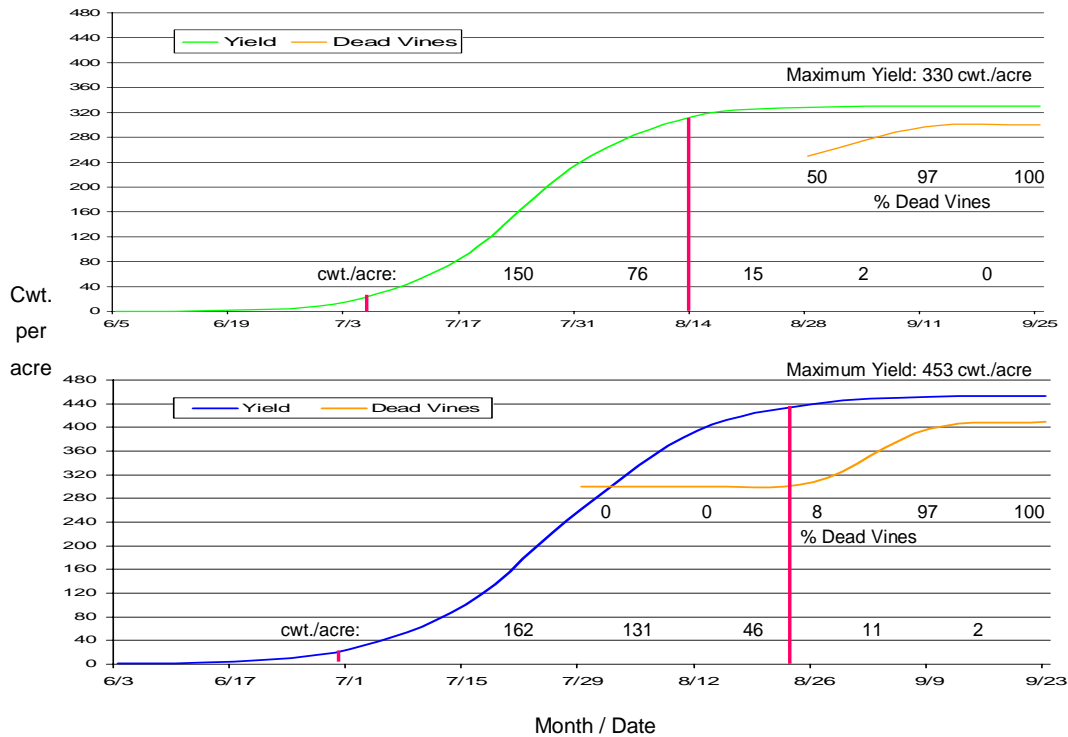
<sup>1</sup> Corsini, et al. 1999.

<sup>2</sup> Abrasive peel test ratings where 0=no blackspot and 5=most damage.

<sup>3</sup> Percent dead vines in fields in late August.

<sup>4</sup> R-square values: 1993=0.37; 1994=0.21. Both significant at P=0.01.

With a recommendation to kill potato fields with a seemingly high percentage of green vines may lead some producers to think this will negatively impact yield. Bulking rate research at the Aberdeen R & E Center has shown that as soon as vines begin to naturally die the rate of bulking rapidly decreases. This is especially true for Russet Burbank (Figure 1). Note in 2004 that on August 26 there were 8 percent dead vines (dead stems), but between August 26 and September 23 the yield increased only by 13 cwt. per acre. A more in-depth discussion of bulking rates can be found elsewhere in the 2006 University of Idaho Winter Commodity School Proceedings.



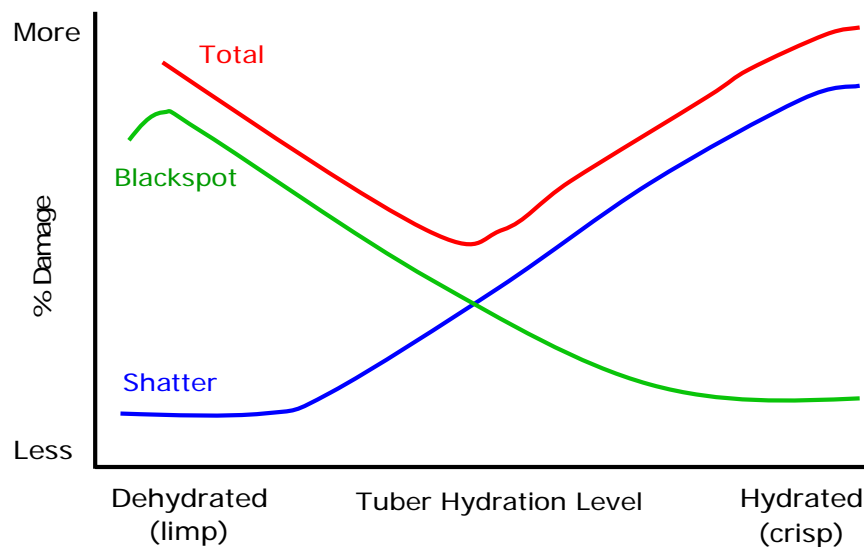
**Figure 1.** Bulking pattern of Russet Burbank in 2003 (top) and 2004 (bottom) at the Aberdeen R & E Center.

Vines should be killed to allow 2 to 3 weeks between killing the vines and harvesting the tubers so the tuber skins have time to set, which lessens susceptibility to skinning and bruising. In areas where cold temperatures during harvest have the potential to damage tubers, vine kill dates need to be scheduled at a time that allows for completion of harvest before freezing temperatures are threatening. Potential freeze dates and other historical weather data can be found on the Internet at <http://www.wrcc.dri.edu>.

**Irrigation Management:** The most likely response of potatoes to irrigation management as it relates to bruise damage is the level of tuber hydration while the tubers are being harvested. Crisp, well hydrated tubers tend to be more susceptible to shatter bruise while limp, dehydrated tubers will blackspot bruise more readily when impacted. After killing the vines, if soil moisture drops below approximately 60 percent available soil moisture, a pre-harvest irrigation will be needed to rehydrate the tubers. Water should be applied at least one week prior to harvest. A light irrigation shortly before harvest to condition the soil for harvest will not be adequate to rehydrate tubers.

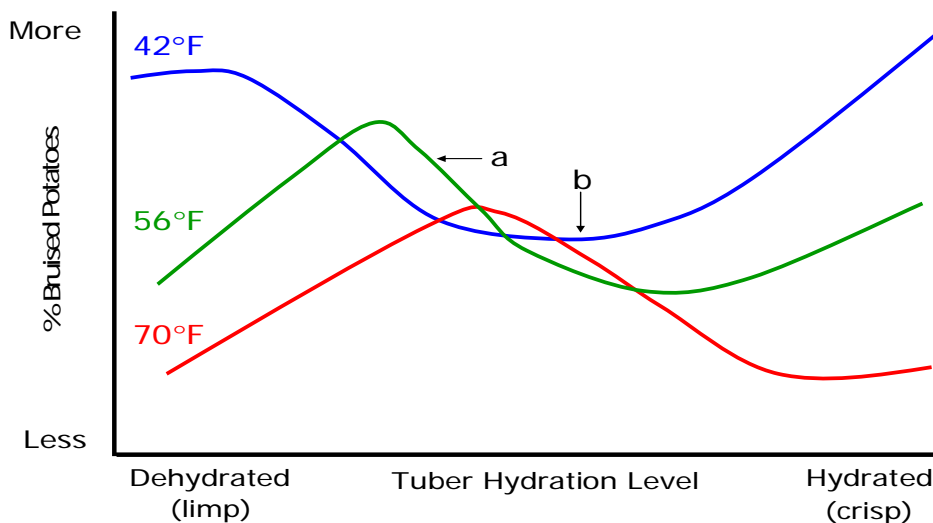
### **TUBER TEMPERATURE AND HYDRATION LEVEL RELATIONSHIPS**

One of the most critical bruise management practices is to harvest tubers at the correct pulp temperature. However, the amount of tuber bruise damage is also associated with tuber hydration level. At any given temperature, shatter bruise will increase and blackspot bruise—if the variety is susceptible to this defect—will decrease as tubers become more hydrated (Figure 2). Therefore, the least total amount of tuber bruising occurs at a point midway between dehydrated and fully hydrated. Unfortunately, there is not a reliable, repeatable test that can ascertain the level of tuber hydration.



**Figure 2.** Effect of tuber hydration level on blackspot and shatter bruise at 42°F. Adapted from Smittle et al. (1974).

The effect of temperature and tuber hydration level on total tuber bruising is fairly straightforward when tubers are either very dehydrated or completely hydrated. As tuber pulp temperature becomes colder, total bruise potential increases at the extremes of tuber hydration level (Figure 3). However, for tuber hydration levels between these two extremes, the effect of tuber pulp temperature is less clear. Compare points “a” and “b” in Figure 3. Note that although point “a” is at a warmer temperature than point “b,” there is a difference in tuber hydration resulting in more total bruise—most likely an increase in blackspot bruise (see also figure 2). You can see there is a fairly wide range of temperatures that will result in the least amount of total tuber bruising when tubers are midway between dehydrated and hydrated. Ideally, tuber pulp temperature while harvesting should be 45°F to 65°F. Although warmer pulp temperatures generally result in less bruise, there is an increased risk of tubers rotting in storage. If harvesting at temperatures above 65°F, be sure the storage facility has the capability to rapidly cool the tubers to less than 65°F.



**Figure 3.** Effect of tuber temperature and hydration on shatter and blackspot bruise susceptibility of Russet Burbank potatoes Adapted from Smittle et al. (1974).

### **HARVESTER TIMING**

Potato tubers are damaged when they strike an object harder than a tuber, but tubers striking other tubers will generally not be damaged. Although all potato harvesting or handling equipment has the potential to bruise tubers, the largest amount of bruising most often occurs on harvesters that are not properly adjusted or operated improperly. When harvester conveyor speeds are properly adjusted, harvester mechanisms will be filled to capacity with potatoes, thus minimizing tuber bruising while at the same time eliminating most of the soil before it reaches the truck.

Properly adjusted harvester conveyor speeds are based on harvesting ground speed. To adjust conveyor speeds, harvesting ground speed must first be determined. After determining ground speed, measure the current speeds of all conveyors on the harvester

to determine if adjustments are needed. A copy of “Harvester Adjustment Worksheets” is included with this article that contains the necessary formulas and information needed to adjust conveyor speeds.

Keep these points in mind when making adjustments to harvester conveyor speeds. The driver sprocket—the gear on the power shaft—is usually the sprocket that is changed because it is less expensive than the driven sprocket, and it comes in a larger assortment of sizes. There are limitations as to the size of sprockets that can be used, especially when replacing a larger sprocket with a smaller one because of roller chain size and shaft diameter. For example, it may not be possible to, say, replace a 14-tooth sprocket with an 11-tooth one because of shaft diameter. It may be necessary to use a sprocket with 12 teeth. Even so, the conveyor speed will still be closer to what it needs to be than before making the adjustment.

One conveyor that you need to pay particular attention to is the rear cross. The reason is because the tubers are not only being dropped from the secondary conveyor, but are also changing direction. To get a visual of how your harvester is operating, abruptly stop the harvester and view the tuber load on the rear cross. A properly adjusted rear-cross conveyor will have tubers piled several layers deep. Seeing a single layer of tubers is a good indication that the rear-cross conveyor is running too fast. Be cautioned, though, that if the rear-cross is slowed too much, there is the possibility of tubers being damaged by the secondary conveyor.

Lastly, adjusting conveyor speeds is based on the harvester traveling 2 miles per hour, otherwise tubers may not properly off-load from one conveyor to the next.

### **FINAL POINTS TO CONSIDER**

Don’t forget to educate all the people working for you about their involvement in managing bruise damage. Educate them about minimizing drops and watching for equipment that may not be operating properly and damaging tubers.

Determining if you have a successful bruise management program should be based on accurate records of the potatoes you sell each year. If the amount of bruised tubers is more than you would like, then implement a bruise management program that encompasses all aspects from planting through harvest. Focusing on bruise management only during harvest may not provide the desired results.

Further information and discussion about minimizing tuber bruising and other topics can be found in “Potato Production Systems,” a book written and published by University of Idaho and the Idaho Center for Potato Research and Education. Log onto <http://info.ag.uidaho.edu/pps/> for more information and to order.

# Harvester Adjustment Worksheets<sup>a</sup>

Producer: \_\_\_\_\_ Date: \_\_\_\_\_

Address: \_\_\_\_\_ Phone: \_\_\_\_\_

Harvester conveyor speeds are based on harvester ground speed so this step must be performed.

## Worksheet for determining harvester ground speed.

Measured distance (feet):				
Tractor Engine Speed for Harvesting (rpm)	Tractor Gear	Time to Travel Measured Distance (seconds)	Ground Speed (ft./min.) <sup>1</sup>	Ground Speed (mph) <sup>2</sup>

<sup>1</sup> (Distance in feet ÷ Time in seconds) x 60 = feet per minute

<sup>2</sup> Divide the answer in the above equation by 88 to get mph. Harvester speed should be 2 mph or more.

## Worksheet for determining conveyor speeds. Machine Identification: \_\_\_\_\_

Harvester Make:		Model:			Number of Rows:		
Conveyor (Use numbers in parentheses to determine desired conveyor speed.) <sup>1,4</sup>	Conveyor Pitch (inches) <sup>2</sup>	Conveyor Head Sprocket (number of teeth)	Conveyor Head Shaft (rpm)	Current Conveyor Speed (ft./min.) <sup>3</sup>	Desired Conveyor Speed (ft./min.) <sup>4</sup>	Current Driver Sprocket (number of teeth)	New Driver Sprocket (number of teeth) <sup>5</sup>
<b>Primary</b> (Sand: 100-120 %) <sup>1</sup> (Heavy: 120-150 %) <sup>1</sup>							
<b>Secondary</b> <sup>6</sup> (65 %) <sup>1</sup>							
<b>Rear-Cross</b> (50-70%; See table below) <sup>1,7</sup>							
<b>Elevator</b> (50-70%; See table below) <sup>1,7</sup>							
<b>Boom</b> (50-70%; See table below) <sup>1,7</sup>							

<sup>1</sup> Numbers are a percentage of ground speed. When using table below, percentage to use is based on the actual amount of harvested tubers going through the harvester. That is, if you are windrowing 4 rows into a 4-row harvester, you would double the field average yield.

<sup>2</sup> To convert chain pitch in millimeters (mm) to inches, use this formula: mm ÷ 25.4 = inches.

<sup>3</sup> (Conveyor pitch in inches x Number of teeth in head sprocket x Head shaft rpm) ÷ 12 = Conveyor speed in ft./min.

<sup>4</sup> Desired conveyor speed is a target speed based on a percentage of harvester ground speed. Use percentages in the first column of this table or the table below. To calculate desired speed, use the following equation:

(Percentage of ground speed x Ground speed in ft./min.) = Desired conveyor speed in ft./min.

<sup>5</sup> When changing the *driver* sprocket, use the following equation to calculate the number of teeth on the new sprocket:

(Desired conveyor speed ÷ Current conveyor speed) x Number of teeth in current sprocket = Number of teeth in new sprocket

When changing the *driven* sprocket, use the following equation to calculate the number of teeth on the new sprocket:

(Current conveyor speed ÷ Desired conveyor speed) x Number of teeth in current sprocket = Number of teeth in new sprocket

<sup>6</sup> The secondary and deviner conveyors should run at the same speed.

<sup>7</sup> These conveyors should not travel less than 100 ft./min.

Chain speeds as a percentage of ground speed based on yield going through the harvester.		
Yield (cwt/acre)	Rear-cross and Elevator	Boom
700	70 %	60 %
600	60 %	55 %
500	50 %	50 %
400	50 %	40 %

<sup>a</sup> Information on harvester timing adapted from: Hyde, G.M., R.E. Thornton, J.A. Francis, and R.E. Hermanson. 1990. Potato Harvester Chain Speed Adjustment. Washington State University. EB1558. (8/28/2001)

### **Information Sources:**

- Bohl, WH. 2003. Harvest Management. *In: Potato Production Systems*. JC Stark and SL Love (eds.). University of Idaho and Idaho Center for Potato Research and Education. Pgs. 345-361.
- Brook, RC (ed.). 1996. Potato bruising: How and why emphasizing blackspot bruise. National Potato Anti-Bruise Committee of the Potato Assoc of America.
- Corsini, D, J Stark, and M Thornton. 1999. Factors contributing to the blackspot bruise potential of Idaho potato fields. *Amer J of Potato Res* 76: 221-226.
- Hyde, GM, RE Thornton, JA Francis, and RE Hermanson. 1990. Potato harvest chain speed adjustment. EB1558. Wash State Univ.
- Smittle, DA, RE Thornton, CL Peterson, and BB Dean. 1974. Harvesting potatoes with minimum damage. *Amer Potato J*: 51: 152-164.
- Stark, JC. 1987. Effect of late-season management on tuber quality. University of Idaho Winter Commodity School Proceedings 19: 82-84.
- Stark, JC and SL Love. 2003. Tuber Quality. *In: Potato Production Systems*. JC Stark and SL Love (eds.). University of Idaho and Idaho Center for Potato Research and Education. Pg. 341.