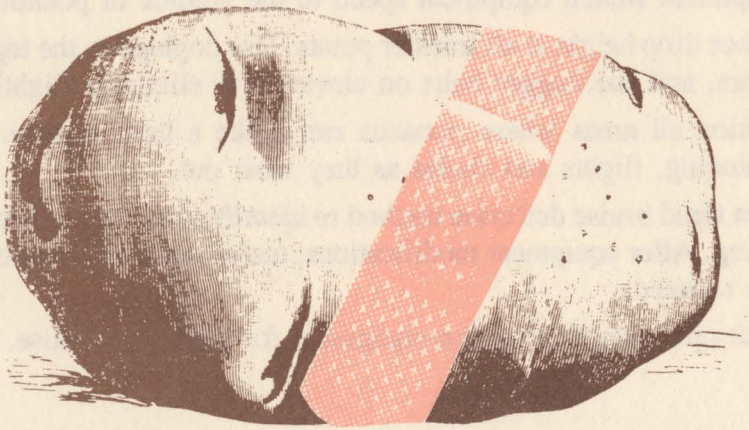
COOPERATIVE EXTENSION SYSTEM
Bulletin No. 725

Bruise-Free Potatoes

Our Goal



Information assembled by members of the National Potato Anti-Bruise Committee of the Potato Association of America

University of Idaho
College of Agriculture

Keys to reducing bruise

- Avoid tillage practices that create clods. Rotate fields to increase organic matter content and improve soil texture.
- Promote tuber maturity at harvest by planting early, achieving uniform stands, avoiding excessive nitrogen fertilizer and allowing adequate time between vine death and harvest.
- Irrigate just before harvest to soften clods and ease soil separation on the harvester. Avoid soil moisture conditions that result in very limp (dehydrated) or very crisp (hydrated) tubers at harvest.
- Harvest and handle potatoes only when they are warmer than 45°F.
- Adjust the relationship between harvester ground speed and chain speed so that conveyors are filled to capacity. Avoid underfilling all handling equipment. Match equipment speed to the volume of potatoes.
- Reduce drop height at all transfer points. Use doglegs on the tops of conveyors, and use hugger belts on elevators to eliminate flights.
- Cushion all areas where potatoes can strike a hard surface. Replace cushioning, flights and chains as they wear out.
- Use a rapid bruise detection method to identify areas where bruise is occurring. After equipment modifications, test to make sure that bruise has been reduced.
- Teach operators how to run equipment for minimum bruise.

Acknowledgments — This University of Idaho Extension bulletin was developed with support from the National Potato Council and National Anti-Bruise Committee through the U.S. Department of Agriculture (USDA) Cooperative Potato Research Program (USDA agreement no. 58-5114-8-1008). Any opinions, findings, conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the USDA.

Bruise-free potatoes: Our goal

Information assembled by members of the National Potato Anti-Bruise Committee of the Potato Association of America

Editors

Gary Kleinschmidt, former Extension potato specialist, University of Idaho, Twin Falls

Michael Thornton, Extension potato and onion specialist, University of Idaho, Parma

National Anti-Bruise Committee members and contributing authors

R. Gary Beaver, Southern Idaho Agricultural Research and Consulting, Parma, Idaho

Roger Brook (vice-chair), Extension agricultural engineer, Michigan State University, East Lansing

Gary Franc, Extension plant pathologist, University of Wyoming, Laramie

Neal Hallee (chair), Extension agricultural engineer, University of Maine, Orono

Gary Kleinschmidt, former Extension potato specialist, University of Idaho, Twin Falls

Edwin Plissey (secretary), Extension potato specialist, University of Maine, Orono

Duane Preston, area Extension potato agent, University of Minnesota, East Grand Forks

Roland Roberts, Extension vegetable specialist, Texas A&M University, College Station

Michael Thornton, Extension potato and onion specialist, University of Idaho, Parma

Robert Thornton, Extension horticulturist, Washington State University, Pullman

Glenn Vogt, J. R. Simplot Co., Caldwell, Idaho

Contents

Bruise-free potatoes: Our goal

Potato bruising has long been considered a serious problem in the potato industry. The effects of bruising are felt by every handler of potatoes and continue to be a major economic drain on the industry. For years now, growers have been reminded that bruising costs money. Every time potatoes are bruised or damaged, regardless of where in handling it happens, the cost is eventually passed back to the grower. Potato bruising is estimated to cost U.S. growers at least $125 million annually or $8,330 for each potato producer.

Bruising costs the potato industry because

- It increases storage losses due to shrinkage and disease
- It increases labor costs for trimming and inspecting
- It increases the cost of the raw product through greater trim losses
- It lowers the quality of the final product
- It increases the incidence of disease in fresh market potatoes in transit and at the market and decreases shelf life
- It reduces the appeal of fresh potatoes to wholesale and retail customers
- It reduces the performance of seed potatoes because of increases in the physiological aging process

Processor records indicate that up to 50 percent of tubers delivered in some lots show evidence of bruise damage. Even a tuber that grades U.S. No. 1 may lose 5 to 6 percent of its weight on the trim line after peeling as a result of bruising.

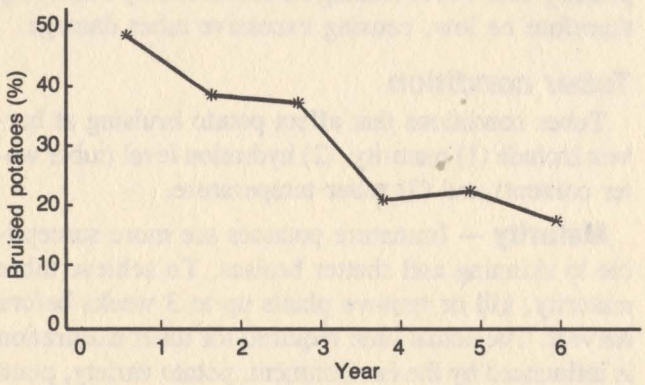


Fig. 1. Bruise reduction observed by processor after incentives were included in the processing contract.

In response, some potato processors have developed potato purchasing contracts that reward producers for bruise-free potatoes. These incentives, plus the knowledge that bruising can be reduced without reducing harvest rates, have decreased the amount of bruising at harvest.

One western processor reduced harvester-caused bruising to 20 percent from 50 percent by implementing bruise incentive programs and using current bruise reduction technology (Fig. 1). Another major processor using bruise incentive payments and bruise reduction technology reduced total bruise to 20 percent from 67 percent over a 6-year period.

In both cases, bruising was reduced without any redesign of harvesting or handling equipment. The basic change was that conveyor chains were kept full of material. Proper chain loading was accomplished by increasing the forward speed of the harvester without increasing conveyor chain speed.

With bruise-free incentive clauses in processor contracts and an increasing emphasis on limiting external grade defects, growers need to develop season-long management plans to prevent bruising. They should be especially aware of four factors that have a major influence on the amount and severity of bruise: (1) soil conditions, (2) tuber condition, (3) equipment maintenance, adjustment, operation and modifications and (4) magnitude of tuber impact.

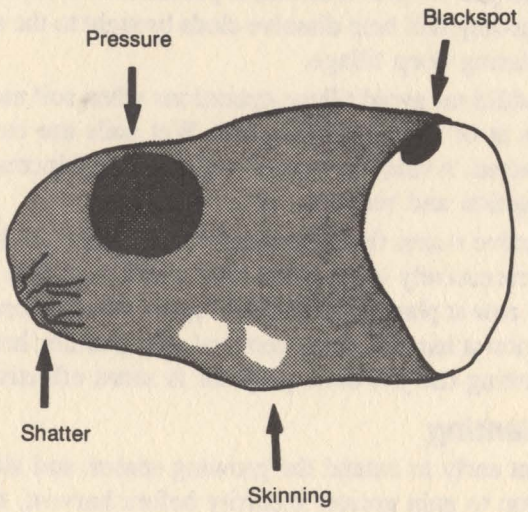


Fig. 2. Types of bruise on potato tubers.

Types of bruise

There are four major types of potato bruise: skinning, blackspot, shatter bruise and pressure bruise (Fig. 2). The first three result from impact of the potato with objects such as equipment, clods, rocks or other tubers during harvesting and handling operations.

Blackspot occurs when the impact crushes cells in the tissue just beneath the skin without actually breaking the skin. Within 2 days the damaged tissue turns a dark color that can be seen only when the potato is peeled.

Shatter bruise results when impacts cause cracks or splits in the potato tuber skin. They may extend into the underlying tissue. Diseases such as Fusarium dry rot and bacterial soft rot easily invade tubers with shatter bruise.

Skinning occurs when immature tubers are handled roughly, resulting in the skin being scuffed and rubbed off. This type of bruising is also called feathering. Skinned areas exposed to wind and sunshine or to dry air may turn dark and may be unacceptable for the fresh market. The dark areas are called scald.

A pressure bruise on a tuber is a flattened or depressed area that develops in storage. It usually results from tuber dehydration caused by low soil moisture before harvest and/or by inadequate humidification of ventilation air in storage.

Bruise prevention before harvest

Preplant

In spring, plowing, disking or cultivating wet soil results in the formation of clods, particularly in clay or silty soils. These clods persist into harvest and, when hard or dry, increase the levels of blackspot, shatter bruise and skinning.

To avoid clod formation, deep chisel plow to break up hard pan the previous fall, if possible. Soil freezing and thawing will help dissolve clods brought to the surface during deep tillage.

In addition, avoid tillage operations when soil moisture is at or near field capacity. Wet soils are easily compacted. Avoid unnecessary tillage, which increases compaction and reduces soil airspace.

Remove stones from the field before planting to help keep excessively large rocks from being buried in the potato row at planting. This pays big dividends in bruise reduction at harvest. Stone removal after planting helps, but getting the job done preplant is more effective.

At planting

Plant early to extend the growing season and allow the crop to gain greater maturity before harvest, thus adding bruise resistance. Avoid excessive nitrogen fertilization, which delays maturity and can result in an increase in bruising at harvest.

Plant for uniform stands. Excessive skips in stands mean variable crop maturity, greater bruise susceptibility and uneven loading of the harvester. Uniform stands result in uniform tuber flow in the harvester. Uniform tuber size and maturity at harvest reduce bruising.

Set planters to achieve the proper row spacing between wheel tracks. Use a modified tillage bar behind the planter to break up planter wheel tracks and reduce early-season clods. Use tillage teeth behind wheels in all operations to reduce clod formation. Do not use excessively wide tires in row crop operations.

Rotate fields to increase and maintain high organic matter levels, which reduce soil crust formation, improve water-holding capacity and keep tilth optimum for bruise reduction. Organic matter will also give the soil texture to resist clod formation and reduce water puddling in wheel tracks.

Bruise prevention at harvest

Use an integrated approach to maximize the percentage of bruise-free potatoes. Harvest under ideal temperature and soil conditions, match the volume of material flowing through the harvester to the capacity of the harvester, and eliminate or minimize sources of injury to avoid excessive bruising even when harvesting and operating conditions are not ideal. The causes of bruise during harvest are a mystery only to those who fail to think about how bruising occurs and to closely observe what happens to the potato on its way from the digger blade to the boom end.

Soil moisture

Irrigation just before harvest softens clods so they break apart rather than scrape against tubers in the harvester. However, high levels of soil moisture at harvest require increased bed agitation to separate tubers from soil. This increases tuber damage.

Dry, sandy soils separate rapidly from tubers on the primary bed. Tuber loading on the secondary chain may therefore be low, causing excessive tuber damage.

Tuber condition

Tuber conditions that affect potato bruising at harvest include (1) maturity, (2) hydration level (tuber water content) and (3) tuber temperature.

Maturity — Immature potatoes are more susceptible to skinning and shatter bruises. To achieve tuber maturity, kill or remove plants up to 3 weeks before harvest. The actual time required for tuber maturation is influenced by the environment, potato variety, plant vigor, fertility and the amount of disease.

Hydration — Soil moisture at vine kill and harvest affects tuber hydration level. Limp (dehydrated) tubers are susceptible to blackspot. Shatter bruises are usually more common in cold or crisp (hydrated) potatoes. Potatoes harvested at 45° to 50°F bruise less when their hydration level is halfway between limp (dehydrated) and crisp (hydrated) (Fig. 3).

Temperature — As tuber temperature increases, less bruise occurs. This is most dramatic in highly hydrated tubers. The percentage of bruised potatoes increases dramatically when tuber pulp temperatures fall below 45°F (Fig. 4). Potato tuber temperature (or 4-inch soil temperature) should be above 45°F and below 65°F during all digging and transfer operations.

The severity of potato bruising is influenced by the time of day tubers are harvested. In early morning soil temperatures are lowest; thus, the amount of bruise is highest. In mid-afternoon, when soil temperature and potato tuber temperature are highest, tuber damage tends to be lowest (Fig. 5).

Soil temperatures in individual fields may vary from regional soil temperatures due to conditions within the field such as soil water, organic matter content, soil texture and environmental factors. Measure soil or tuber temperature to determine the best time to harvest potatoes in a specific field. This can easily be done with an inexpensive pocket dial thermometer. Periodically check the accuracy of the thermometer.

Harvester operation

Studies of harvester operation have revealed that the most important factor influencing bruising is not ground speed or chain speed alone but the ratio of chain speed to ground speed (Table 1). These studies have shown that to minimize bruising, the chains must be kept full of potatoes or full of potatoes and other material. Often the harvester ground speed is too slow for the chain speed. The solution is to increase forward speed, thus speeding up harvest and smoothing out the flow of tubers through the harvester.

Table 1. Chain speed to ground speed ratios for 500 to 600 cwt yield.

Chain	Chain speed as percentage of ground speed
	(%)
Primary, sandy soil	100 to 120
Primary, heavy soil	120 to 150
Secondary*	65
Rear crossover*, elevator* and boom	50 to 60

*Speed should be no slower than 100 feet per minute.

Harvester modifications

Equipment modifications can further reduce harvest bruise. The modifications discussed here are not intended to cover all the possible injury-reducing modifica-

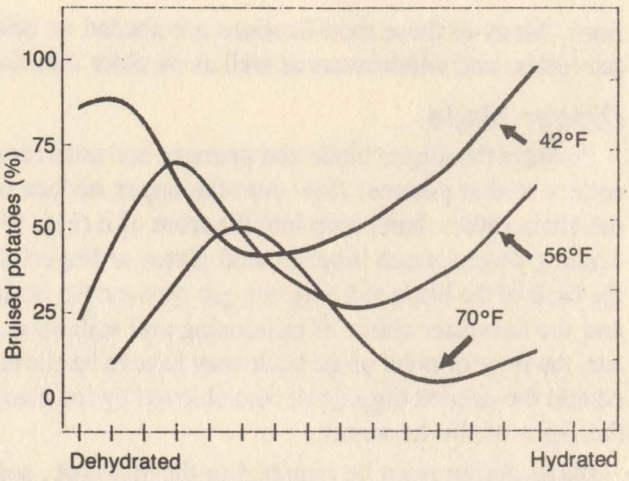


Fig. 3. Effect of tuber temperature and hydration level on blackspot and shatter bruise susceptibility.

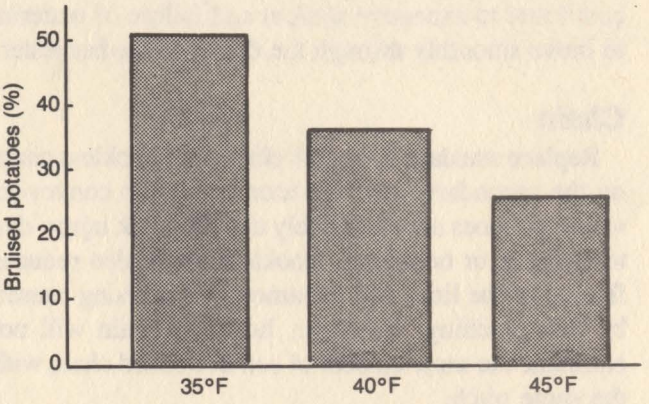


Fig. 4. Effect of tuber temperature on bruise damage.

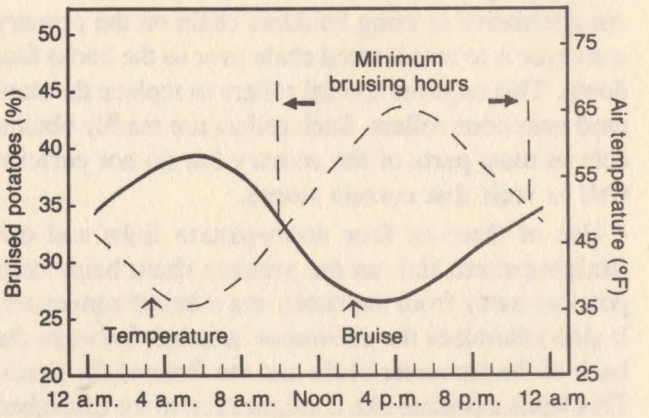


Fig. 5. Effect of time of day on bruise damage in fall-harvested potatoes.

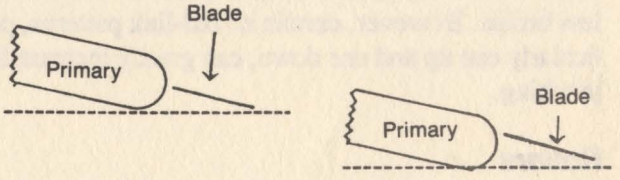


Fig. 6. At left, the blade jams tubers into the front of the chain. A blade tangent to the primary (right) causes less bruise.

tions. Many of these modifications are needed on new harvesters and windrowers as well as on older models.

Digger blade

Position the digger blade and primary bed nose cone rollers so that potatoes flow onto the upper surface of the chain rather than bump into the front of it (Fig. 6). Some growers attach hinged metal plates or fingers to the back of the blade to bridge the gap between the blade and the harvester chain. If bulldozing and spillout occur, the front or point of the blade may have to be elevated and the needed digging depth achieved by lowering the front of the harvester.

Blade design must be matched to the soil type, soil conditions, presence of plant roots (especially alfalfa and weeds) and depth of tuber set. An improper blade, a dull blade or a blade that is not scouring freely can contribute to excessive spillout and failure of material to move smoothly through the throat of the harvester.

Chain

Replace standard hook link chain with hookless chain on the secondary, side elevator and boom conveyors where potatoes are most likely to suffer link injury due to rollback or bouncing. Hookless chain also reduces flexing of the links and the amount of bruising caused by link pinching. However, hookless chain will not eliminate the same amount of soil as hooked chain with the same pitch.

Hookless chain on the primary conveyor wears out more rapidly and eliminates less soil than hooked chain. An alternative to using hookless chain on the primary conveyor is to turn hooked chain over so the hooks face down. This requires special rollers to replace the standard nose cone rollers. Such rollers are readily obtainable in most parts of the country but do not perform well in soils that contain stones.

Use of three or four down-pattern links and one straight-pattern link on the primary chain helps keep potatoes away from the hooks and sides of conveyors. It also minimizes the difference in height between the back of the harvester blade and the front of the chain. This lends a pocket-like configuration to the chain bed that reduces the tendency of potatoes to roll back.

A mixture of link types, such as four down and one straight, can also increase soil separation and improve tuber flow. This results in less need for shakers and less bruise. However, certain mixed-link patterns, particularly one up and one down, can greatly increase link pinching.

Rollers

Except on doglegs, all rollers on conveyors should have the same diameter and be mounted at a uniform height to avoid humps in the chain that increase rollback. Use small rollers (maximum 4-inch diameter on the primary conveyor) to minimize height and slope of the chain, to further reduce drop height and to reduce rollback.

To reduce drop height, choose the smallest available drive sprocket size. A change in drive sprocket size will require recalculation and adjustment of chain speed.

Worn sprockets and bearings and rollers that are not moving freely cause jerky movement of chains, which contributes to rollback. Lubricate rollers and replace worn sprockets and bearings.

Primary conveyor

On split bed harvesters, cover the center support bar on the primary conveyor with tubing. This will pad the bar and move potatoes away from link ends.

Whenever possible, operate without shaking the chain. Hydraulic shakers are better than mechanical shakers because shaker frequency can be adjusted from the tractor cab.

Reduce the height of the drop onto the secondary chain by modifying the discharge end of the primary conveyor. Make a dogleg by repositioning the drive sprocket, reducing drive sprocket size and repositioning or enlarging the last set of glide rollers.

Secondary conveyor

Install a sloped block of wood or metal covered with cushioning on each side of the secondary conveyor bed where it receives tubers from the primary. This will divert tubers away from the ends of the deviner and secondary chains.

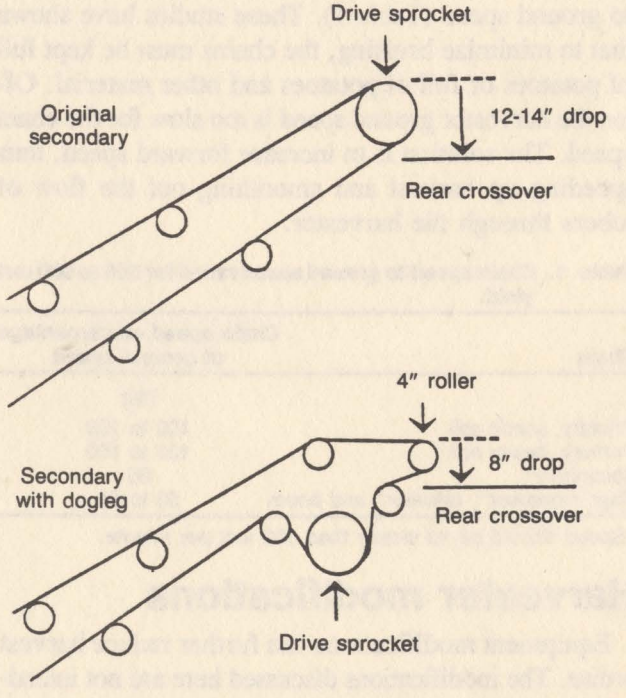


Fig. 7. Dogleg modification of secondary conveyor.

On split-bed harvesters cover the center support bar on the secondary bed with cushioning and replace the cushioning when it is worn. If the secondary has flights, replace them if they are worn, bent, broken or otherwise defective.

Modify the upper end of the secondary conveyor to minimize the drop to the rear crossover. This includes installing a dogleg with a reverse-side drive (Fig. 7). This may not be possible if your machine has a split secondary. If possible, use smaller diameter drive sprockets to further reduce the drop. As on the primary conveyor, use small diameter rollers. On split secondary conveyors, extend the boom side partway over the rear crossover to ensure an even distribution of tubers on the rear crossover.

Deviner chain

The deviner chain is one of the most frequent sources of bruising injury on both harvesters and windrowers. Tubers often bounce on the deviner chain, causing them to tumble several times before falling onto the secondary conveyor.

Deviner links should be covered with padding. When the link padding starts to wear off, replace the entire chain or individual links.

To minimize bouncing and tumbling and prevent excessive rollback on the secondary, remove the first one or two sets of deviner rollers so the deviner chain rides on top of the secondary chain. In this position the deviner links act as flights partway up the secondary chain (Fig. 8). This will allow removal of flights from the secondary chain and shorten the drop from the secondary conveyor to the rear crossover.

Another option is to install a blower to remove vines and eliminate the deviner chain altogether. In that case, the distance tubers fall from the primary to the secondary can be shortened significantly.

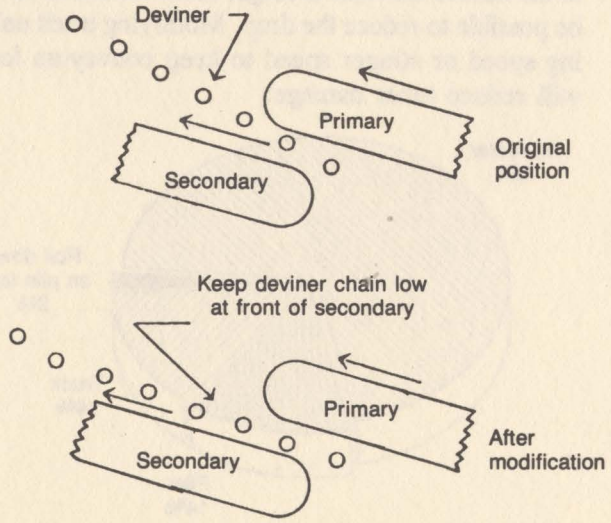


Fig. 8. Deviner chain positioning for reduced tuber damage.

Rear crossover

The drop from the secondary conveyor to the rear crossover chain is one of the longest on the harvester. Use a chain covering on the rear crossover that will provide maximum cushioning.

One serious source of injury on many older harvesters is the inside corner where the downstream end of the rear crossover conveyor meets the side elevator. If the load and distribution of tubers are not correct, tubers often get caught in this corner, becoming severely damaged. Tubers may also be sucked through the hole in this corner and fall to the ground. Installation of a padded shield to cover the hole may be helpful, but the only satisfactory solution is to extend the rear crossover partway over the side elevator.

Some older models have a revolving, cylindrical roller beneath the end of the rear crossover. Its function is to remove smaller pieces of trash such as grass. Unfortunately, it can pull tubers under the rear crossover where they either fall to the ground or are damaged. Extending the rear crossover as described above will lessen this problem. Inactivating the roller by removing its drive chain will also help.

Side elevator

The length and slope of this conveyor provide opportunities for tuber rollback that can result in an excessive amount of injury. A flighted chain can help reduce rollback. Use flights that are stiffer or heavier on the wing portion to help reduce rollback of tubers coming up the side of the conveyor. To minimize rollback, put in a flight every eighth link instead of every ninth or tenth. Replace all broken flights.

Better yet, eliminate all flights on the side elevator and install a hugger belt. A hugger belt is much more effective than flights and less expensive. If volume on the chain is unusually heavy, tuber movement under the hugger belt may be excessive. In that case, install 3/4-inch risers on the hugger belt. Eliminating the flights allows substantial shortening of the drop from the top of the elevator to the clod eliminator or sorting table.

Cover or close the gap between the edge of the elevator chain and the side of the conveyor bed. Use rounded bolts to attach a strip of 1-by-4-inch wood to each side of the conveyor. Bevel the end of the wood so that tubers do not get caught against its edge.

Lower the top of the elevator toward the sorting table or clod eliminator table. Install a dogleg similar to that described for the top of the secondary chain (Fig. 7).

Clod eliminator table

Clod eliminator tables of any kind are a potential source of injury, particularly to long tubers such as those of Russet Burbank. Every grower needs to seriously

ask if a clod table is needed by determining the trade-off between less dirt tare and a higher number of bruise-free tubers. Do not use clod tables unless you need them for dirt and trash removal.

Rollers on clod tables can quickly become caked with soil. As a result, the trend is to switch to star rollers. Regardless of the type of roller, bruises can result if the tubers bounce, roll or tumble excessively while on the clod eliminator table. Damage also occurs when tubers are flipped, flung or bounced from the clod eliminator table onto the sorting table.

Roller speed appears to be much more important than roller design. If a clod table is required, regulate the speed of the rollers to minimize injury while removing soil, small clods and debris.

Sorting table

Injury frequently occurs on the sorting table when the protective covering along its sides wears out. On some harvesters the flanged roller, located near the boom end on each side of the sorting table, becomes exposed when its belting wears out. Tubers may bump into it, get caught behind it and start tumbling, or get cut by the flange. Replace this belting if it shows signs of wear.

Sometimes metal deflectors are attached to the side of the sorting table to funnel the flow of tubers away from the table edge. Tubers may get caught underneath these deflectors and get pinched, scraped, cut or otherwise bruised. Modify the shape and position of the deflectors to eliminate damage.

Some harvesters have a boxlike metal shield with pointed corners on each side of the boom end of the sorting table. When the inboard section of the boom conveyor is lifted at a fairly steep angle to clear the sideboards of the truck and to top it off, tubers on the boom frequently roll back and hit this shield. Wrap the shield with some kind of cushioning.

Boom conveyor

A hugger belt may be installed on the boom conveyor if rollback is excessive. Otherwise, make sure flights are in good working order and undamaged. Use flights with stiff wings and install them every 12 to 16 inches. As on the other conveyors, look for places where tubers may be scraped, bumped, caught or where tumbling and rollback are likely.

Installing an electronic boom control device to automatically control the height of the boom conveyor as the truck is being filled will also help reduce damage. An automatic boom control device also allows the harvester operator to pay more attention to chain loads, ground speeds and other operating parameters to further reduce tuber damage.

Harvester operator

All operators should be trained to manage the harvester properly and to minimize bruise. A careless operator can cause a significant amount of bruise.

Bruise prevention in potato piling operations

Studies show that about 30 percent of all bruise can occur during trucking and piling operations (Fig. 9). Examination of these operations reveals some causes of injury and some ways to reduce it.

Tarping the truck

Often, the driver walks down the center of the truck to spread the tarp, causing unnecessary tuber damage. The amount of damage can be reduced if drivers wear soft-soled canvas shoes. If possible, they should spread the tarp from the ground or by walking down each side of the truck. Recently, mechanical methods for load tarping have been developed. This eliminates the need to walk on the potatoes.

Unloading the truck

The person pulling the boards can do a lot of unnecessary damage by kicking or stomping on the potatoes to get them to feed onto the unloading belt. Instead, potatoes should be worked down carefully. An excessive amount of dirt in the potatoes makes unloading them without injury very difficult. Match the speed of unloading to the capacity of the receiving operation. To do so, change motor pulley size to achieve the desired unloading speed.

Stinger

Keep the receiving end of the stinger as close as possible to the unloading belt. Older stingers may need remodeling to get the needed reduction in drop from the belt to the stinger. Where the drop from the stinger to the incline elevator is large, some modification may be possible to reduce the drop. Modifying truck unloading speed or stinger speed to keep conveyors loaded will reduce tuber damage.

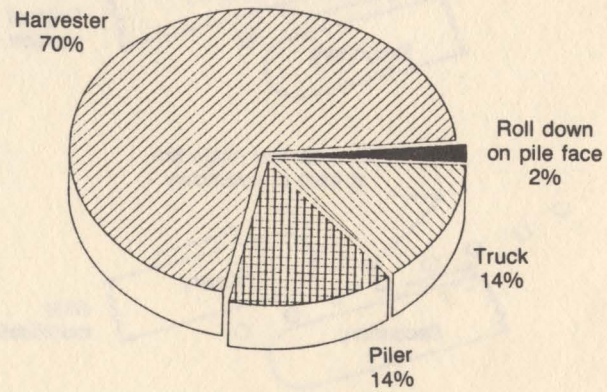


Fig. 9. Sources of mechanical injury to potatoes.

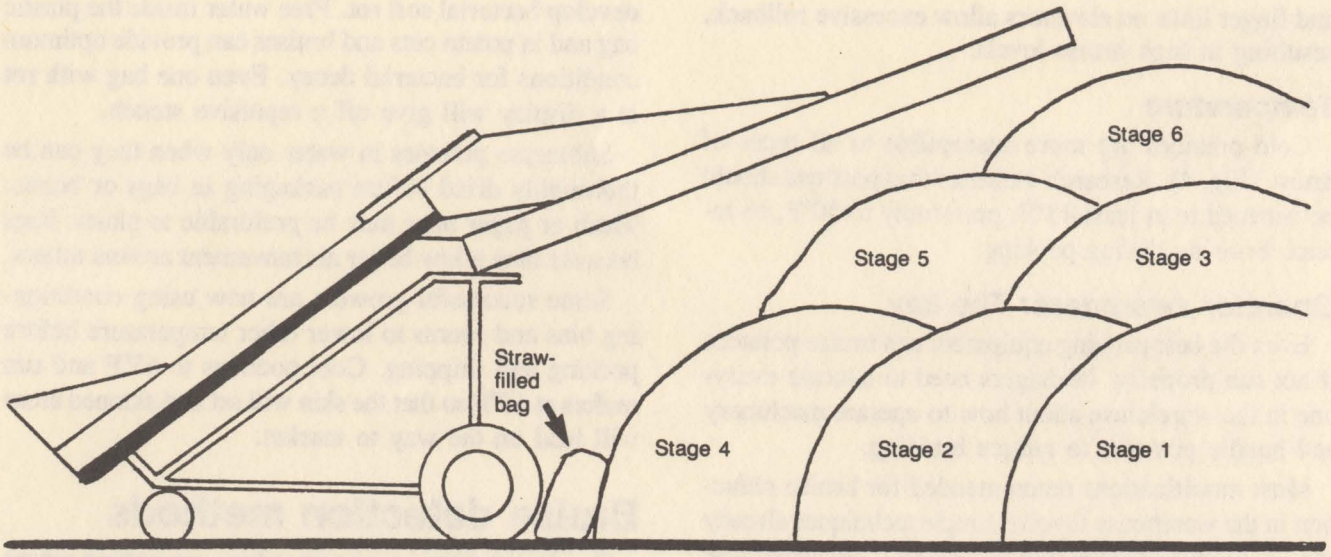


Fig. 10. Progressive potato piling procedure.

Piler

To reduce the amount of potato injury that occurs in the piler, set the piler chain or belt speed so that the piler operates with a full, even flow of potatoes. This will reduce the effective drop at transfer points.

It is very important to keep the piler boom as close as possible to the potato pile. A common mistake is for the operator to move the boom away from the pile to accomplish other tasks or to avoid giving the piler constant attention. Not only does this increase the drop and likelihood of damage, but because a larger portion of a truckload is unloaded at one spot in the pile, it increases the probability of a dirt pocket forming. Large portions of the pile also have a greater tendency to slide down, making it difficult to keep the boom close to the top of the pile.

Use a progressive or stepwise piling procedure to prevent rollback (Fig. 10). The top of the pile can be kept more uniform by moving the piler shorter distances more often. A piler with a telescoping boom is easier to manage while building a pile with a uniform top.

Bruise prevention in the warehouse

Surveys of fresh pack warehouses indicate that some grading and packing operations significantly add to the level of bruise in fresh market potatoes. Excessive bruise may lead to rejection of shipments at their destinations. Shippers lose an estimated $1,600 to $22,500 in revenue for each rejected truckload, depending on whether the load is sold at a discount, resorted or dumped.

One way that shippers can take a direct role in helping reduce losses due to bruise is by eliminating bruise during packing. The factors that follow are common causes of bruise in warehouses.

Belt speed

Bruise during the packing operation is often associated with underloading of belts and chains. Fill conveyors to capacity by slowing belt speeds or increasing tuber volume. Elevators with flights operated at high speeds throw the potatoes onto the next belt, causing considerable bruising.

Sizing rollers that are running too fast cause potatoes to bounce across them before dropping onto the next belt. Run sizing rollers at speeds that allow a gradual flow of potatoes across the rollers.

Drops

Considerable bruising can occur where drops are greater than 6 inches. Loading potatoes into an even-flow bin is one of the primary activities that cause bruise. Methods to reduce bruising in even-flow bins include keeping them full at all times and using padding in a stair-step arrangement to reduce the drop into the bin.

Many warehouses have excessive drops at the main elevator into the warehouse. These drops could be reduced by moving the drive sprocket into a dogleg arrangement (Fig. 7) or elevating the potatoes with something other than flighted chain such as a V-belt or hugger belt. Warehouses that use bulk scoop loaders to supply potatoes to the packing line must be especially careful to operate the machinery properly to reduce the drop height from the bucket.

Cushioning and flights

All areas of the packing line where potatoes can strike a hard surface should be protected with cushioning fastened with rounded bolts. Check the cushioning frequently and replace it as it wears out. Broken flights

and finger links on elevators allow excessive rollback, resulting in high bruise levels.

Temperature

Cold potatoes are more susceptible to all types of bruise (Fig. 4). Research indicates that potatoes should be warmed to at least 45°F, preferably to 50°F, to reduce bruising during packing.

Operator awareness: The key

Even the best packing equipment can bruise potatoes if not run properly. Managers need to educate everyone in the warehouse about how to operate machinery and handle potatoes to reduce bruising.

Most modifications recommended for bruise reduction in the warehouse involve simple techniques already used to reduce bruising during harvest. One warehouse that adjusted its equipment based on the factors discussed here reduced serious bruise damage in count cartons by more than 60 percent. Warehouse managers and growers need to work together to minimize bruising in order to provide consumers with quality, bruise-free potatoes.

Spring and summer fresh market potatoes: Special considerations

Bruises in spring and summer fresh pack potatoes cause financial loss and frustration to everyone from the grower to the consumer. Bruising in spring- and summer-harvested potatoes is especially serious because high tuber temperatures promote rapid tuber breakdown. Preventing bruise and bruise-related rot in potatoes harvested during warm weather is a serious challenge.

Spring and summer crops are usually harvested while the plants are actively growing. The vines are killed and may be removed before harvest to prevent them from becoming tangled in the harvester and to promote skin set. However, immature tubers from these plants bruise and skin easily as they slide, roll and bump their way through harvesting and handling equipment.

Promote tuber maturity and skin set by controlling nitrogen fertilization. Available nitrogen in soil and petioles should have decreased to a low level before vine kill and harvest. Allow adequate time between vine kill and harvest. Although some of these methods may reduce yield, they are necessary for best-quality potatoes.

Keep all parts of handling equipment full by calibrating and modifying chain and ground speeds. Maintain sufficient moisture in the hill to permit the potatoes to separate easily from the soil.

When fresh market potatoes are packed in plastic bags while wet from the washer, or when moisture condenses on the insides of plastic bags, bruised potatoes often develop bacterial soft rot. Free water inside the plastic bag and in potato cuts and bruises can provide optimum conditions for bacterial decay. Even one bag with rot in a display will give off a repulsive stench.

Submerse potatoes in water only when they can be thoroughly dried before packaging in bags or boxes. Mesh or paper bags may be preferable to plastic bags because they allow better air movement around tubers.

Some successful growers are now using conditioning bins and rooms to lower tuber temperature before packing and shipping. Cool potatoes to 65°F and run reefers at 65°F so that the skin will set and skinned areas will heal on the way to market.

Bruise detection methods

To identify harvesting or handling equipment where damage occurs or to identify problem locations on individual pieces of equipment, it is essential to measure damage. Several detection methods are available. Some readily lend themselves to use in the field. They can be used on harvesters, pilers or any other potato handling equipment, allowing machine operators to see the bruises that occur when their machines are in operation.

A potato harvester should be checked at every point where potatoes change chains or direction. For example, tubers can be checked just ahead of the harvester and again after the digger blade. Bruise registered between these two locations would indicate a maladjusted digger blade or crushing by the tractor tires.

An increase in damage from one chain to the next indicates where adjustments need to be made. Check all the drops in a potato harvester to see if damage is occurring from excessive drop. Potatoes can also be selected at random from the truck and compared with potatoes in the pile to determine damage caused by the piling operation. If any modifications are made, tubers can be checked again to determine if the modifications have decreased the amount of bruising.

Blackspot damage can be checked by collecting potatoes from an operation and holding them for 48 hours at room temperature or for 6 to 12 hours at 90°F. After the holding period, peel the potatoes and inspect them for blackspot. By the time blackspot develops in the 48-hour test, the operation's handling conditions could have changed. Therefore, the more rapid test is preferred and has successfully provided next-day results.

Two rapid chemical detection methods have been developed. The catechol method can detect bruises that break the skin (skinning, shatter bruise and cuts) in less than 20 minutes. It will not detect blackspot. The tetrazolium method allows detection of blackspot in 10 to 40 minutes.

Catechol method

1. Wash a random sample of potatoes (about 10 tubers) and place them in a small bucket with holes in the bottom. Immerse this bucket in a larger bucket containing the catechol testing solution (2 ounces catechol per gallon of water).
2. After approximately 1 minute in the test solution, lift the small bucket and allow the solution to drain out.
3. Allow the potatoes to dry for 5 to 7 minutes. The time required for staining will increase as the solution becomes older and weaker and as tuber temperature drops. Under these conditions, let the potatoes dry longer.
4. Lightly peel the potatoes. Bruised areas will show up on the surface as dark red or purplish stains.
5. Evaluate the bruises. ***Skinning*** — one stroke of a peeler removes all visible damage. ***Slight bruise*** — two strokes of a peeler remove all damage. ***Serious or severe bruise*** — more than two strokes of a peeler are required to remove all damage. If the sample contains 10 tubers, the amount of damage on the tubers can easily be expressed as a percentage.

Because catechol is a toxic chemical, wear rubber gloves and destroy all potatoes used in the test.

Tetrazolium method

1. Prepare a solution of 1 percent 2,3,5-triphenyl tetrazolium chloride in tap water.
2. Collect a random sample of potatoes to be checked for bruise, wash off their dirt and thinly peel them.
3. Place the peeled tubers in the solution for about 40 minutes.
4. Bruises will appear as dark pink areas in as few as 10 minutes and as many as 40 minutes. The reaction and intensity of stain are improved by conducting the test in sunlight and by using warm water (70°F).
5. Destroy all potatoes used in the test as the chemical is toxic to humans and livestock.

Sources of bruise detection chemicals

Schweizerhall
10 Corporate Place South
Piscataway, NJ 08854
(908) 981-8200

Curtiss Laboratories, Inc.
2510 State Road
Bensalem, PA 19020
(215) 245-8833

Eastern Chemical
Box 2500
Smithtown, NY 11787
(516) 273-0900

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
(800) 325-3010

Sources of further information

Ag Publications Building, Building J40, University of Idaho, Moscow, ID 83843, (208) 885-7982

CIS 534, *An Automatic Boom Control for Potato Harvesters*

CIS 835, *Potato Harvesting and Handling Operations for Quality, Efficiency and Safety*

Videotape 275, "Potato Bruise Prevention: #1 The Harvester"

Videotape 471, "Potato Bruise Prevention: #2 Harvester Chain Adjustment"

Videotape 586, "Potato Bruise Prevention: #3 Handling"

Bulletin Office, Washington State University, Pullman, WA 99164-5912, (509) 335-2857

EB 646, *Reducing Potato Damage During Harvest*

EB 1080, *Reducing Potato Harvesting Bruise*

EB 1558, *Potato Harvester Chain Speed Adjustment*

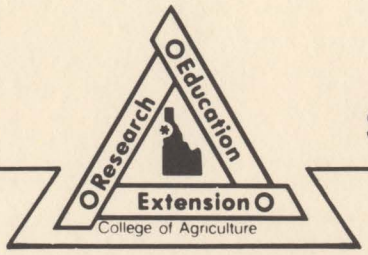
State Publications Office, 111 Libby Hall, Cooperative Extension, University of Maine, Orono, ME 04469, (800) 287-0274

Bulletin 2160, *Prevent Potato Bruising During Harvest*

Bulletin 2149, *Potato Bin Piler Selection to Operation*

Bulletin Office, Michigan State University, 10B Agriculture Hall, East Lansing, MI 48824-1039, (517) 355-0240

E-2074, *Potato Bruising*



SERVING THE STATE

Teaching . . . Research . . . Extension . . . this is the three-fold charge of the College of Agriculture at your state Land-Grant Institution, the University of Idaho. To fulfill this charge, the College extends its faculty and resources to all parts of the state.

Extension . . . The Cooperative Extension System has offices in 42 of Idaho's 44 counties under the leadership of men and women specially trained to work with agriculture, home economics and youth. The educational programs of these College of Agriculture faculty members are supported cooperatively by county, state and federal funding.

Research . . . Agricultural Research scientists are located at the campus in Moscow, at Research and Extension Centers near Aberdeen, Caldwell, Parma, Tetonia and Twin Falls, and at the U.S. Sheep Experiment Station, Dubois, and the USDA/ARS Soil and Water Laboratory at Kimberly. Their work includes research on every major agricultural program in Idaho and on economic activities that apply to the state as a whole.

Teaching . . . Centers of College of Agriculture teaching are the University classrooms and laboratories where agriculture students can earn bachelor of science degrees in any of 20 major fields, or work for master's and Ph.D. degrees in their specialties. And beyond these are a variety of workshops and training sessions developed throughout the state for adults and youth by College of Agriculture faculty.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, LeRoy D. Luft, Director of Cooperative Extension System, University of Idaho, Moscow, Idaho 83843. We offer educational programs, activities and materials without regard to race, color, religion, national origin, sex, age or disability, in accordance with state and federal laws.

2,000 August 1991

$1.00