IMPORTANT ASPECTS OF POTATO SEED CUTTING AND SEED PIECE BRUISE

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ABSTRACT

The economic consequence of physical damage in commercially produced potatoes has become increasingly important to growers, packers and processors in recent years. Consequently, a great deal of effort and expense has been focused on bruise reduction, and generally with good success. Recent studies suggest these concerns may not have been as effectively applied to potatoes grown for seed. Perhaps even more alarming are some of the cut seed piece handling practices in accepted use today.

The impact of seed cutting practices and seed bruising have been examined in a two year field study. This project was designed to compare the influences of sharp vs. dull seed cutting knives and the effects of productivity of bruising on whole seed and cut seed pieces. Results indicate some dissimilar damage susceptibilities for various sites on cut seed pieces. Problems associated with knife sharpness are discussed. The relationship between cut surface bruises and the incidence of seed piece decay is addressed. The number of bruises per seed piece as it relates to overall decay severity and subsequent effects on reduced plant stands, weak plants, decreased yield, crop quality and grower profit will be presented.

Of all the aspects in potato production that offer significant potential for improvement with minimal cost increase, perhaps none are more promising than the efforts involving a reduction of physical damage in whole and cut seed. Much of the field research done recently indicates yield increases of 20% and more may be possible, even probable. Crop performance increases are not always guaranteed with seed bruise reduction, however, since there are a great many other variables involved in growing a crop. There is, none the less, solid evidence of yield declines associated seed handling injury from pre-harvest through storage, delivery, cutting, and finally planting. Studies done in Idaho indicate about one third of the total yield reduction occurs as a result of handling injury before the seed is cut and the balance of yield loss (67%) is due to bruising after the seed is cut.

The explanation for this observation may be more complex than we currently understand completely. Part of this relationship, however, stems from the fact that whole potatoes are much less susceptible to bruise than are cut seed pieces even though whole tubers may be individually much heavier.

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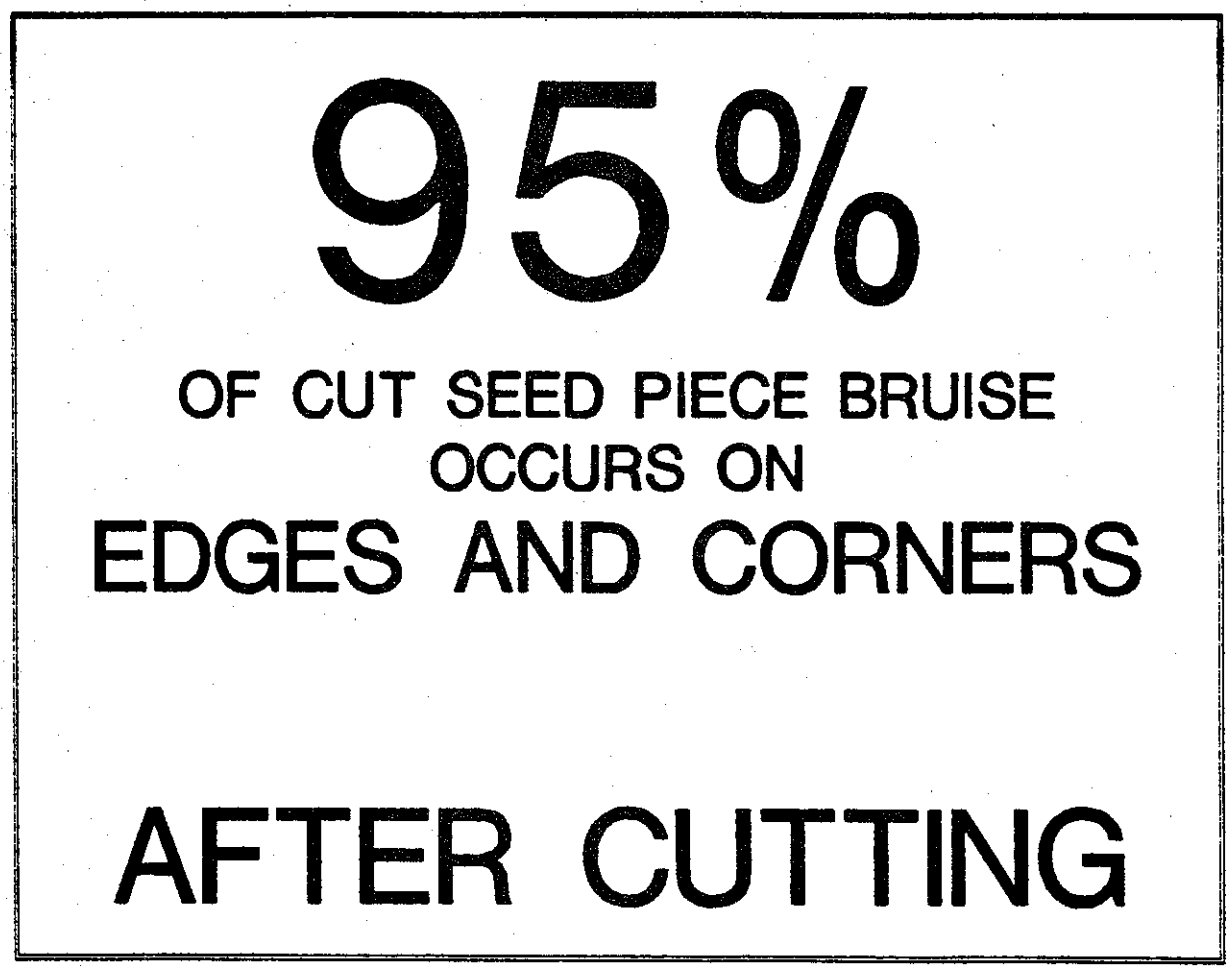
It is also generally agreed that big potatoes are more likely to be bruised than are smaller whole seed potatoes. These differences are due to the weight/impact energy differences and more importantly the amount of cell tissue that absorbs the impact energy. Field evaluations indicate more than 95% of the bruises that occur after seed is cut are located on these edges and corners.

Figure 1.



In a recent lab test hand cut seed pieces weighing 2-1/4 ounces were prepared from an exceptionally crisp (turgid) potato sample.

Figure 2.

2 1/4 OZ. SEED BRUISE SUSCEPTABILITY
RUSSET BURBANK

BRUISE LOCATION	3 INCH DROP	6 INCH DROP
CORNER	93%	100%
⟨ 90º EDGE	89%	100%
90º SKIN EDGE	88%	100%
90º CENTER EDGE	82%	97%
WHOLE SEED	0%	6%

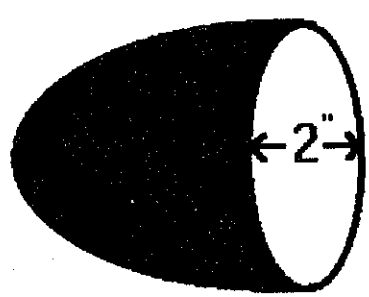
55 DEGREE SEED TEMPERATURE

Each of these pieces had three cut surfaces similar in shape to the center sections from large tubers cut on a mechanical cutter where both vertical and horizontal knives are used. All of these evaluations were done at 55 degrees F to approximate the temperature of seed potatoes commonly preferred at planting time. An extremely sharp knife was used to produce very clean cut surfaces and make the detection of crushed cells (i.e. bruises), even the very small ones, detectable. These tiny damage sites were recorded as bruises because, even though they were small, the number of cells destroyed in an impact is in the hundreds or perhaps thousands. Compared to the size of the pathogens that can cause seed piece decay these sites are huge. This data in Figure 2 clearly indicates just how fragile cut seed can be. It is important to recognize that this may very well be a worst case situation because very few seed potato lots are this turgid at cutting time as this one was.

Make whatever allowances you like for the unusual condition of my sample, then consider the consequences of the level of bruise I found with a 3 inch drop if that level of damage were to occur with six inch or even twelve inch drops in a less firm seed lot in your operation. Better yet, do your own informal test. Seed drop heights of about one and a half times the distances shown in figure 2 where one seed piece impacts on another produce very nearly the same bruise levels as did the seed hitting equipment surfaces. Think for a moment about how many drops there are from the cutter to the planted seed where drop heights less than 12 inches exist (if any) and then how many there are that are greater than 12 inches (some are a whole lot more than 12 inches). Perhaps this helps to focus on the magnitude of the job we have ahead of us. Based on our findings and many observations made at commercial operations, it is very obvious that CUT SEED IS THE MOST FRAGILE POTATO TISSUE GROWERS WILL EVER WORK WITH. It is also important to recognize that the energies of impact needed to cause bruise damage in cut seed is much less than that required to bruise whole seed potatoes. Commercial cut seed handling practices however, do not indicate an understanding and acceptance of this relationship.

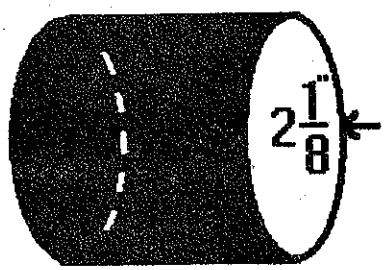
While I do not expect to ever see totally bruise free cut seed, I do believe there is much we can do to reduce both the number and severity of the injuries we are currently experiencing. I also expect most of this progress will be in the form of equipment modification, redesign and cushioning applications. We can also do much toward achieving our goal by working with smaller whole seed potato sizes. Because of lower whole tuber weights and fewer cut surfaces smaller seed is much less susceptible to damage both before and after cutting. Less vulnerable because seed cut from smaller whole tubers has considerably smaller linear edge dimensions and generally no corners at all compared to the seed pieces cut from larger tubers.

Figure 3.



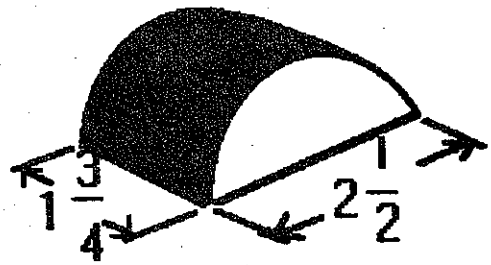
6.28 inches of edge

Figure 4



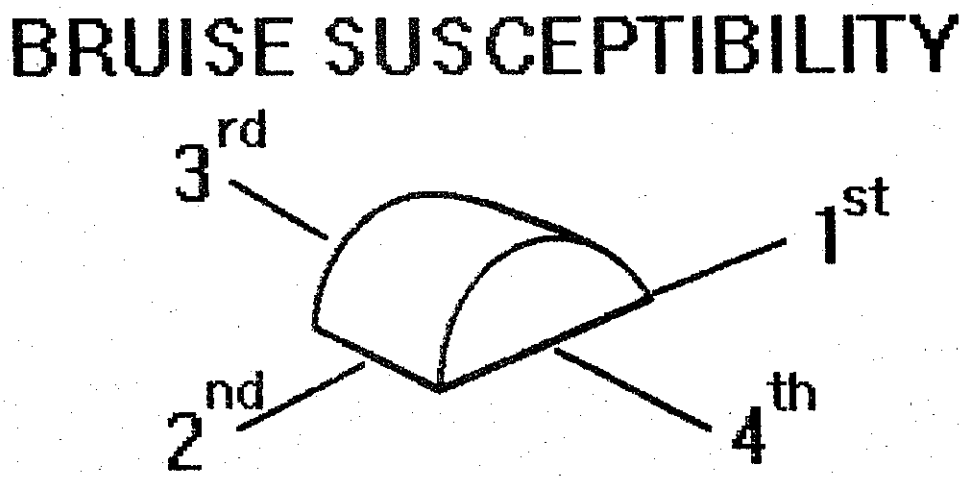
13.35 inches of edges

Figure 5



16.35 inches of edge plus four corners

Figure 6



The way commercial seed cutters are currently designed, the more fragile the seed piece once it is cut, the farther we drop it from the cutting knife. Since our cutters use a flighted elevator chain to bring whole tubers to the uppermost level of the machine it may be possible to use the same concept to bring cut seed back down to the bottom conveyor after it is cut. Perhaps, some on farm modifications of existing cutting equipment could pay handsome dividends in increased productivity with only minimal costs.

Our seed bruising problems don't end with the cutter. The next important damage device is our seed treatment applicators. The auger (grinder) and barrel duster (tumbler) can add additional bruises to each seed piece. The drop into and out of the seed treaters is rarely as little as twelve inches. In each case additional bruises are possible. In our efforts to get the seed into the truck we observe major free fall impacts. Drop distances into the empty truck generally do not exceed ten feet and almost never are less than one foot, so more bruising may occur. As we move seed out of the truck and into our planter loading equipment we experience still more drops and impacts. Many growers still use an elevator, some even a piler for this task. Seed drops out of the truck to the loading equipment are almost always greater than twelve inches and often in the three foot range. More and more we are seeing bucket loading equipment being built by growers themselves. But this is prompted more by the time savings associated with the planter loading than for the bruise reduction benefits. In an effort to reduce the time required to load a planter, the elevator belt is generally run very fast. When falling seed impacts this conveyor belt, considerable rollback occurs before the seed assumes the uphill speed of the elevator. Significant additional bruise damage may be occurring at this point. When the seed reaches the top of the elevator it's trajectory launches it into an impact baffle which causes more damage. The seed then falls into the planter. Seed may drop as much as six feet into an empty planter and again very few drops of less than twelve inches are observed even when the planter is full.

The last source of damge is in the planter itself. The mechanism that feeds seed from the bulk bin is sometimes brutal. Crushed and broken seed is a common occurrence. The use of a pole, pipe, or shovel handle to "harpoon" lodged seed is still a common practice in spite of the severity of this act on seed injury. Finally, the action of the pick arms and the cups moving through the rigid confines of the seed bowl causes compression forces of seed against the walls and bottom of the bowl. Seed has no place to go except up to get out of the way of the moving mechanism. This movement is against the weight of the rest of the seed in the bowl and damage is significant.

When you add all these potential damage opportunities together and consider them collectively it is not difficult to understand why the average cut seed piece has eight new bruises on it by the time it's planted that were not present prior to cutting.

There is yet another newly identified concern which deals with cut seed damage. It relates directly to how sharp the cutting knives are and the thickness and ridigity of these knife assemblies.

Rolling disc knives must be made rigid and sharp enough to perform their function reliably for extended periods with minimal maintenance. They are therefore constructed of fairly thick steel. Assuming these knives are sharp, there is still some potential for cell crushing. The difference in distance between the sharpened leading edges of any two knives and the spacing between their parallel disc surfaces is the "crush" dimension. This dimension is equivalent to the thickness of one knife blade (approximately 1/8 inch). This may be a minor consideration on seed that has lost some of its firmness and is perhaps more important on the very firm seed lots. It is however of minor importance when compared to the level of seed tissue destruction associated with "DULL" knives. Dull knives crush, tear, and fracture seed, sometimes severely. No other part of a properly adjusted mechanical seed cutter can be destructive as are dull knives. Seed cut with dull knives has a reduced production potential and it can generally be avoided.

There is no level or type of bruise in potato production that will make you money. A bruise, is a bruise, is a bruise! Seed bruising carries with it a penalty against productivity. The consequences are proportionate to the amount of damaged tissue. The location of the bruise does matter however. If seed potato bruise occurs prior to cutting and is exhibited as an internal black spot symptom with no break in the integrity of the skin, the problem is then confined to the damaged cell tissue. That is, until the seed is cut and then only if the cut exposes the damaged (Black Spot) tissue. In 1993 we were able to determine that exposed black spot bruised tissue can behave just like any other freshly bruised tissue. Bruises occurring both before and after cutting which occur on freshly exposed tissue as either edges, corners or cut surfaces have the potential consequence of being entry sites for seed piece decay pathogens. Healthy tissue below the black spot bruised tissue can't heal either because of the lack of needed oxygen. This increased vulnerability is the direct result of the inability of bruised cells to accomplish any suberization and wound healing. Damaged cell tissue therefore remains unprotected and highly susceptible to decay. This helps explain some of Dr. Kleinkopf's results in Idaho. More than anything else it is the ambient field conditions that determine how far and how fast decay progresses. Allow at least that there are nearly always sufficient pathogens present. Infection may occur whenever and wherever an exposure to pathogens and ambient conditions favorable to successful infection exist. Since both prerequisites must be satisfied simultaneously, not every bruise site will develop decay symptoms. Our field trial results show 75% and 90% infection in the bruised sites in 1992 and 1993 respectively. In addition, even if decay does become established, the extent of tissue destruction can vary from involving only the crushed tissue to complete decay of the whole seed piece. IN 1992 and 1993, conditions were very favorable for wound healing. This process is especially important during the early part of the season. If it occurs while the seed pieces are acting as an important source of support for the development of the new plant it can be especially serious. Generally seed decay occurring 60 days or more after planting is not a major problem in the Columbia Basin of Washington State. There is also a measurable difference in bruise susceptibility and damage severity between the various sites on cut seed pieces. Corners are clearly the most fragile. Edges where the angle of the two intersecting surfaces is less than 90 degrees, are the second most susceptible sites.

Edges where the angle approximates 90 degrees are slightly less vulnerable and the right angle edges through the center of the tuber are the least vulnerable. They are however much more susceptible to damage than are the cut surfaces and skin covered sides of the seed piece.

In order to determine how the seed piece bruise and dull knife damage affect crop performance, Dr. Bob Thornton of WSU and I have been cooperatively conducting field research on this problem in the Columbia Basin of Washington for the past two years. With respect to what we have learned, the consequences of seed and seed piece bruise relates directly to the INCIDENCE OF SEED PIECE DECAY in proportion to number of bruises and their severity.

Figure 7.

SEED PIECE CONDITION
60 DAYS AFTER PLANTING

SEED SHAPE	BRUISE/KNIFE	SEED INDEX
WHOLE	0 / NA	10.00
1 CUT	0 / SHARP	9.93
3 CUT	0 / SHARP	9.78
3 CUT	4 / SHARP	9.37
3 CUT	0 / DULL	9.35
3 CUT	4 / DULL	9.11
3 CUT	8 / SHARP	9.05
3 CUT	8 / DULL	8.64

SIGNIFICANT AT 1% LEVEL

The primary reason for this relationship is that bruised i.e. crushed i.e. dead cells can neither suberize nor wound heal. Commercial field evaluations also indicate bruise and decay incidence increases rapidly as the number of edges and corners on the cut seed piece increase.

The findings from our field trials in 1992 and 1993 indicate 75 AND 90% RESPECTIVELY, OF THE HAND BRUISED SITES DEVELOPED SOME LEVEL OF SEED DECAY. Consider also that these were years when seed healing conditions were very favorable. One might suspect things could have been much worse. There was a very strongly correlated and statistically significant relationship both years of increased weak plant numbers and failures to emerge (missing plants) associated with knife sharpness and also with elevated seed piece bruise incidence.

Figure 8

CUT SEED DAMAGE VS WEAK PLANTS
Number of Weak Plants "93"

Bruise Level	Knife Condition Sharp	Dull	Total
0	13	16	29
4	24	26	50
8	30	38	68
Total:	67	80	

In other unrelated trials the yield and quality from weak plants has been shown to be substantially lower. The effect of missing plants also has a negative impact on both yield and quality. We also found that STEM NUMBERS ARE INCREASED with higher seed bruise levels. This may or may not contribute to elevated tuber set counts. Other factors such as Rhizoctonia sp. and tuber reabsorption may also have an important influence here.

Figure 9

AVERAGE STEM NUMBER
60 DAYS AFTER PLANTING

SEED SHAPE	BRUISE/KNIFE	STEM NUMBER
WHOLE	0 / NA	3.20
1 CUT	0 / SHARP	2.56
3 CUT	8 / DULL	2.35
3 CUT	8 / SHARP	2.30
3 CUT	4 / DULL	2.25
3 CUT	0 / DULL	2.15
3 CUT	0 / SHARP	2.10
3 CUT	4 / SHARP	1.75

SIGNIFICANT AT 1% LEVEL

Most importantly, YIELD AND QUALITY CAN ALSO BE REDUCED. While our plot data has not shown statistically significant differences at the 95% level, there was a consistent trend in 1992 that paralleled the relationship of negatives associated elevated levels of seed damage. In 1993 the trial was machine planted and very few meaningful differences were observed in yield or tuber size. It is particularly important to recognize that the amount of damage we produced with our dull knife cutting and our hand bruising techniques is MUCH LESS SEVERE than that which can frequently be observed in commercial operations throughout western North America. It is no secret that seed that has been severely abused physically will generally perform below desired expectations.