Influence of Temperature on Harvest Damage

Doyle A. Smittle
Washington State University

Introduction: Mechanical injury of potatoes during harvest is one of the most important problems in the production of potatoes. Mechanical injury is basically of two types, blackspot and shatter bruise. The chemical reactions resulting in black-pigment development of blackspot and shatter bruise are the same. The type of damage resulting from impact depends on the condition of the potato tuber at the time of impact. Drawings of typical blackspot and shatter bruise injuries are presented in Fig. 1. An impact results in a separation of large areas of cells and discoloration of separated areas when potato tubers are very turgid. If the potato tuber is flaccid an impact will result in a crushing of cells and blackspot develops. Potato tubers have been found to be relatively resistant to both types of injury when the tuber is at the proper turgidity level. Two factors play dominant roles in determining the tuber turgidity level.

Temperature: Research conducted by Johnston (1) in Maine illustrates the relationship of soil temperature and incidence of shatter bruise. The extremes of soil temperature encountered at different times of day would be less on cloudy days and nights than shown in Fig. 2, but would be greater on clear days and nights. The minimum soil temperature and most severe shatter bruise occurred at 8 A.M. while the highest soil temperature and least severe bruise occurred at 5 P.M.

Using this information and a cost of 40¢ per ton for each percentage increase in bruise the loss to the grower can be calculated. The loss resulting from various 12 hour harvest periods during a day is presented in Table 1.

A reduction of loss due to bruise damage presented can be expressed as profit since harvest speed was constant resulting in essentially the same cost of harvest at all periods of the day.

Table 1. Cost of shatter bruise damage resulting from different 12 hour harvest periods (cost calculated at 40¢/ton/% bruise).

	6AM - 6PM Bruise 8%		6AM - 6PM Bruise 12%	
Harvest Period	20T/A	25T/A	20T/A	25T/A
6AM - 6PM	$64.00	$80.00	$96.00	$120.00
7AM - 7PM	57.60	72.00	86.40	108.00
8AM - 8PM	51.20	64.00	78.40	98.00
9AM - 9PM	48.00	60.00	69.60	87.00
10AM - 10PM	45.60	57.00	62.40	78.00
11AM - 11PM	45.60	57.00	58.40	73.00
Noon - Midnight	46.40	58.00	59.20	74.00

A potato grower harvesting from 6AM - 6PM with a bruise damage of 8% can make a profit of about $22.00 by shifting his harvest to 11AM - 11PM. This profit results from a reduction of bruise damage from 8% to 5.8%. When harvesting from 6AM - 6PM results in an $120.00/acre loss (12% bruise 25/A), a $46.00/acre profit can be realized by shifting harvest to 11AM - 11PM.

The data indicate that a larger differance in bruise damage may result from shifting the harvest period when the 6AM - 6PM damage is greater.

Another series of experiments were conducted by Johnston and Wilson (2) to determine the influence of temperature on resistance to bruising of potatoes harvested at different maturities. The height of drop of a 0.6 pound metal weight required to rupture the flesh increased linearly with increasing tuber temperature (Fig. 3). When early and late harvest were analysed separately only 28-54% of the variation in bruise damage was accounted for by tuber temperature. If the two harvest periods were analysed together temperature accounted for only 12% of the variation in bruise resistance.

The results of dropping tubers 12 inches onto a digger chain (Fig. 4) are very similar to the standardized bruising studies. Katahdin and Russet Burbank varieties were used in this study. Tuber temperature accounted for 48% of the bruise variation in Katahdin variety and 18% in Russet Burbank.

Tuber condition: If temperature accounts for only 18% of the variation in bruise damage of Russet Burbank variety, it is obvious that some other factor or factors play an important role. Preliminary studies indicate that 40-50% of the variation in shatter bruise at a given temperature can be accounted for by variation in tuber turgidity. With the method used, tuber turgidity accounted for about 20-30% of the variation in blackspot. One of the factors which results in changes in tuber turgidity is the hydration level of the cells. The relation of tuber hydration levels to blackspot and shatter bruise damages are presented in Fig. 5. A very dehydrated tuber may be relatively resistant to blackspot and very resistant to shatter bruise. A slight increase in hydration may result in an increase in blackspot, but further hydration results in a decrease in blackspot until the tubers become resistant to blackspot. This is not the entire story because susceptibility to shatter bruise increases as tuber hydration level increases. Therefore, when attempting to determine the best level of tuber hydration at which to harvest both blackspot and shatter bruise damages should be considered.

Another factor which results in a change in tuber turgidity is tuber tempertature. Preliminary data indicates that the relationship of temperature and tuber dehydration to total damage susceptibility (blackspot and shatter bruise) is similar to that shown in Fig. 6. When tuber temperatures are high shatter bruise is not a problem and hydrated tubers are more resistant to damage. But if these potatoes are harvested at a low temperature shatter bruise will be very severe resulting in a large amount of total damage. The dehydration level resulting in minimum total damage of potatoes harvested at medium temperatures may result in moderate to severe blackspot if harvested at high temperature.

The level of damages at the hydration level of minimum damage indicates that lower temperatures result in some rigidity of cell walls. Cell wall rigidity tends to increase susceptibility to both blackspot and shatter bruise. Therefore, potatoes must be handled more carefully when tuber temperatures are low. The general pattern of damage susceptibility appears similar for all temperatures used.

How could the temperature-tuber hydration information be used?

1. A potato grower could condition his potatoes to obtain the maximum damage resistance (hydration level of minimum damage) at the temperature which he expects to harvest.

2. The period of day in which harvesting is done could be adjusted to most closely meet the temperatures in which the potatoes have been conditioned to be harvested.

3. The rate at which harvesting is done would need to vary during the harvest period depending on the tuber temperature.

4. The rate of harvest during a day's harvest could be adjusted to obtain a maximum harvesting rate with low damage.

Problems:

1. One of the main problems will be variation in tuber condition. The condition of hydration level varies:

   a) within a potato field.

   b) within a hill of potatoes.

   c) within a potato tuber.

2. A good inexpensive method of determining tuber condition has not been developed at the present time. These two problems are under investigation at the present time. After they have been worked out, the most critical problem will be up to you the potato grower.

3. Implementation - This will involve careful planning of your entire potato production program. As an example, you will need to know the approximate date of harvest prior to the time you purchase your seed because your entire fertilization, irrigation and pest control program may vary depending on the temperature at harvest.

Literature Cited

1. Johnston, E. F. 1968. Are traditional hours of harvesting potatoes obsolete? Research in the Life Sciences. Summer: 24-31.

2. Johnston, E. F. and J. B. Wilson. 1969. Effect of soil temperature at harvest on the bruise resistance of potatoes. Am. Potato J. 46:75-82.

Fig. 1. A drawing of typical blackspot and shatter bruise injury.

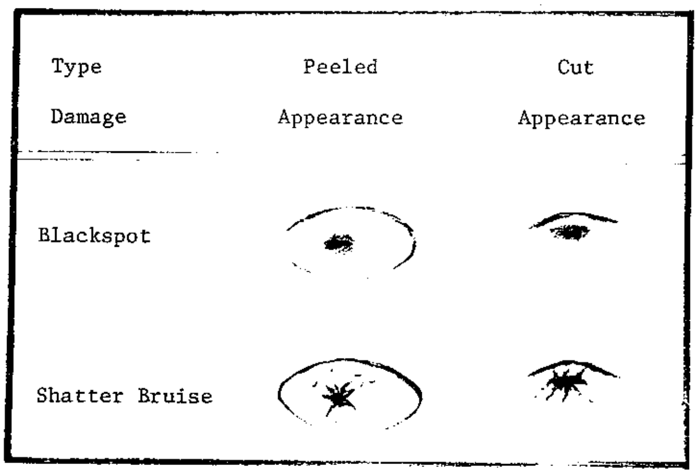

Fig. 2. Temperature range and estimated damage resulting when average 6AM - 6PM damage equals 12%.

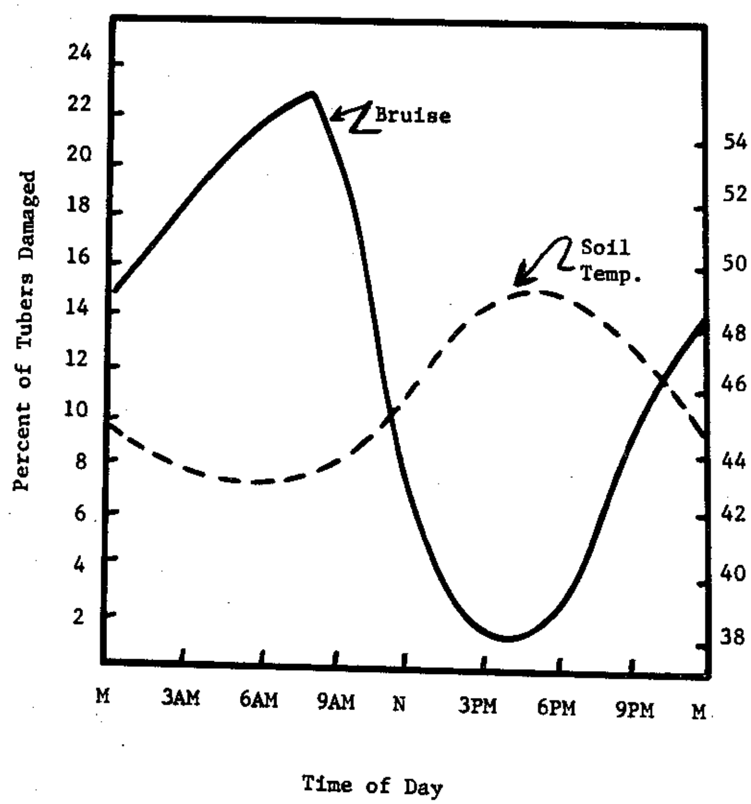

Fig. 3. Bruise resistance as related to temperature and harvest period (standardized bruising).

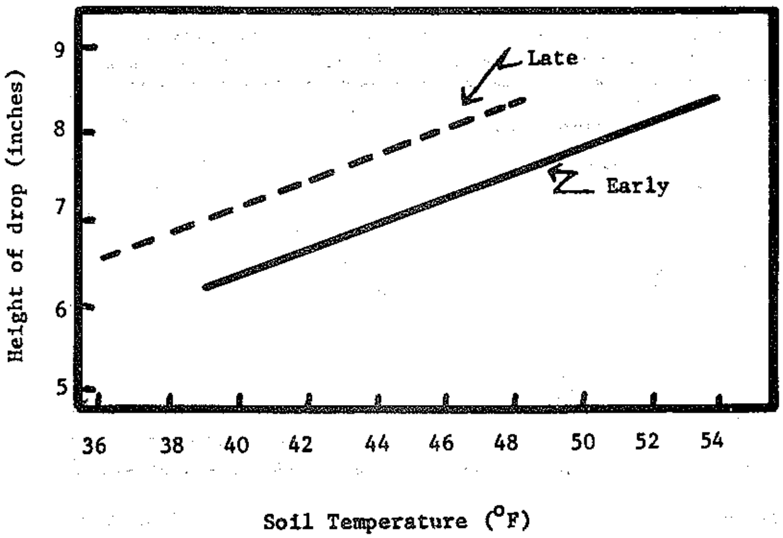

Fig. 4. Bruise resistance as related to temperature and harvest period (tubers dropped 12").

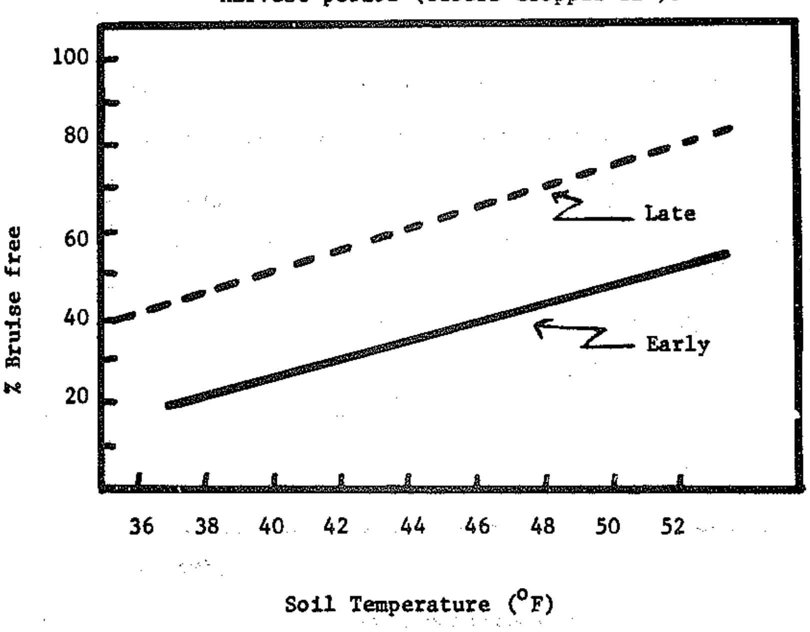

Fig. 5. Blackspot and shatter bruise susceptibility as affected by temperature and tuber hydration level.

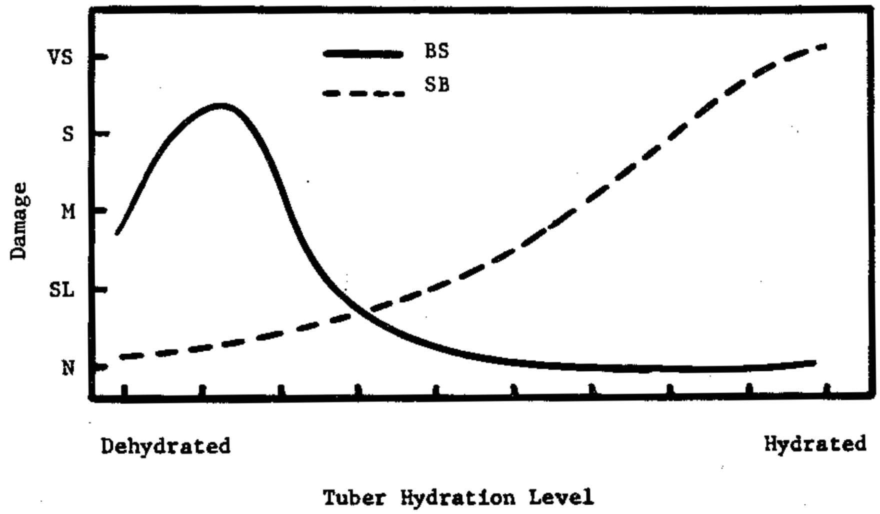

Fig. 6. Total damage susceptibility as affected by temperature and tuber hydration level.