POTATO BRUISING IS INFLUENCED BY MORE THAN HARVESTER

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INTRODUCTION

Descriptive terms such as blackspot, shatter, cracking and pressure bruise have been used to characterize tissue damage identified with potato tuber injury (3, 14, 19). The damage, that may or may not break the periderm of the tuber, is the result of a bruising force (6, 14) received during harvest and/or post-harvest handling. A major factor in the magnitude of bruising is the speed, distance, and shape of the force applied. Also, tubers of a given cultivar or among cultivars subjected to a known force do not express the same degree of tissue damage, whether blackspot or shatter bruise develops (4, 10, 17). This suggests that there is a component of tuber tissue conditioning that accounts for the differences in bruise response among tubers (18). A review of literature on cultural practices in the western region of America revealed that at harvest there are four factors that influence the degree of tuber tissue damage sustained: 1) the status of the soil physical condition; 2) the conditioning of tuber tissue; 3) the temperature of tuber tissue; and 4) the operating of the harvester.

The soil physical condition and potato tuber moisture and temperature are influenced by the soil moisture content which in part is controlled by cultural and irrigation practices. The physical conditioning of the tuber at harvest can be influenced by the inherent characteristics of the soil (compaction, aeration, drainage, diseases, nutrient availability) and by the irrigation and fertilizer practices imposed.

Influence of Soil Physical Condition

The moisture content, soil type and degree of compaction of the soil influences the ease with which potato tubers separate from the soil at harvest (1, 15). A wet, clay-like soil is difficult to separate and remove from tubers. When faced with such a condition, the harvest operator tends to decrease the forward speed of the harvester. This results in an increase in chain speed to ground speed ratio. This change in speed ratio results in greater chain agitation and an increase in the velocity of tuber movement on the chain. An increase in tuber bruising is likely (15). Chain shakers may be used in an attempt to increase soil separation. However, the use of shakers and/or an increase in the magnitude of shaking enhances the likelihood of greater tuber damage (20). A dry, clay-like soil readily forms clods. Vigorous shaking increases the frequency of potential clod-tuber contact and the damage to tubers increases (19).

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In contrast to a dry, clay-like soil, a dry, sandy soil easily separates from tubers and forms no clods. This exposes tubers to direct contact with the hard surface of the primary chain of the harvester and tuber damage increases. Where possible, irrigation to attain optimum soil moisture conditions prior to harvest can be helpful in reducing the potential damage inflicted on tubers during harvest. The knowledge and experience of the harvester operator to adjust to soil conditions can make a significant contribution towards lowering the magnitude of bruising damage of tubers during harvest (15). A soil moisture content of between 60 and 80 percent of field capacity provides conditions for desirable soil load with optimum separation and minimum tuber damage (15). Where irrigation is available, the application of water prior to harvest can assure a desirable soil moisture content.

Change in the soil moisture content (impaired drainage, compaction, excessive irrigation) has an affect upon the soil atmosphere. The CO_2 content of the soil atmosphere rises as the soil water content increases to near saturation. In California, an increase in the severity of blackspot bruise of White Rose cultivar was associated with an increase in the concentration of CO_2 and a decrease in O_2 of the soil atmosphere at tuber depth (3, 21). The lowest incidence of blackspot occurred in dry soil (Figure 1). In contrast, in Washington the susceptibility of Russet Burbank cultivar to blackspot was not altered by raising the CO_2 content in the soil atmosphere. Susceptibility to blackspot bruise was highest in tubers located shallow in drier soil (Table 1) (8). The contradictory responses are yet to be resolved. The soil atmosphere contains other gases whose concentration and presence also may have an affect upon the susceptibility of tuber tissue to blackspot bruise. The presence of ethylene, under certain conditions, may have contributed to a change in tuber susceptibility to blackspot (17).

Tuber Tissue Conditioning

The physical and physiological status of tuber tissue at the time of bruising impact affects not only the magnitude of damage but also the type of bruise injury: blackspot, shatter, cracking and pressure bruise (6, 14). Tuber hydration significantly affects the occurrence of blackspot (6, 8) (Table 2). Smittle et al (14) outlined this response based on their research and literature review for blackspot and shatter bruise (Figure 2). As the moisture content of a tuber shifts from a turgid (hydrated) to a flaccid (dehydrated) state, the tuber becomes more susceptible to blackspot but gains greater resistance to shatter bruise. Upon rehydration, susceptibility is reversed (Figure 3). Tuber temperature can alter the magnitude of damage (Figure 4). Tuber cracking seems to be influenced by the degree of tissue hydration in a manner like that present with shatter bruise injury. A pressure bruise is believed to result from pile pressure exerted among tubers that are becoming less turgid with time in storage and approaching the tuber moisture status associated with blackspot susceptibility at harvest (19). Tuber hydration can in part be regulated by cultural practices that maintain optimum soil fertility, minimize pest and disease infestation, and uniform soil moisture content through irrigation and proper foliar desiccation management (14).

Soil Fertility and Plant Nutrition

Of the nutrients necessary for plant growth, nitrogen and potassium are most often cited as influencing tuber conditioning related with bruise susceptibility (3, 7, 11). Nitrogen fertilization can alter tuber size distribution, dry matter content (specific gravity) and maturity of tubers (7, 9, 12, 13). With a high to excess level of available nitrogen throughout plant growth, tuber maturity is delayed and dry matter accumulation is slowed. Tubers with lower specific gravity results (7, 9, 16). Total tuber yield may or may not be affected depending upon harvest date. Low levels of available nitrogen or where non-uniformity in fertilizer application occur result in uneven plant growth with differing tuber maturity and bruise susceptibility. Tuber specific gravity has been used as a means of measuring relative maturity, and changes in gravity have apparently affected bruise susceptibility. However, wide variability in responses among cultivars as well as among tubers of individual plants has indicated that tuber specific gravity alone is not sufficient to explain bruise susceptibility (3, 5, 7, 8, 9). Kunkel and Gardner (6) recognized this and proposed that tuber hydration was more reliable than specific gravity as an indicator for evaluating tuber bruise susceptibility.

In California, it was demonstrated that a high incidence of blackspot occurred in tubers from plants that tested low in potassium (11). Significant lower tuber blackspot susceptibility resulted when plants were grown with adequate potassium fertilization; however, tuber maturity was a factor. Younger (less mature) tubers showed a lower susceptibility than did older (mature) tubers. In Washington (9), high potassium fertilization resulted in a lower incidence of blackspot and lower specific gravity of tubers (Figure 5). These responses suggested to Kunkel (7) that a change in irrigation practices had been a factor. A discontinuation of irrigation affected the hydration of tubers. Delay in harvest altered the status of moisture of tubers and their susceptibility (Figure 6). When nitrogen and potassium availability is high, plant and tuber maturity will be delayed and have an influence on tuber conditioning, i.e., specific gravity and tissue hydration.

Irrigation Management

Plant growth and potato yield response to irrigation and fertilizer management are influenced by the uniformity or lack thereof in soil physical condition within and among fields under production. Hammond and Mulla (2), using a grid sampling technique, showed that seemingly uniform soils can differ substantially in the level of available nutrients. Irrigation management interacts with fertility management (Figure 7). The rate of soil water movement is dependent upon the physical condition of soil and the movement of applied nitrogen and residual nitrogen in the soil profile is dependent upon the amount and frequency of irrigation applied (1). It is not uncommon to find that irrigation (sprinkler) patterns do not distribute water uniformly. This results in non-uniform plant growth and tuber maturity and hydration.

Harvester Operation

Although irrigation and fertilizer management can influence both soil physical and tuber tissue conditioning there is another component of the tuber bruise susceptibility equation that needs to be considered. That is the impact force introduced during harvester operation (Figure 8). Adapting harvester operation to field physical conditions has shown to be effective in reducing tuber damage during harvest (15). It is not likely that complete bruise damage control is possible even within a given field; but, where possible, conditioning tubers to be more resistant to bruising (Table 2, Figures 3 and 4) will provide more operational leeway than when tubers are bruise susceptible (15).

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Table 1. Relationship of tuber depth, soil moisture, tuber specific gravity and blackspot of Russet Burbank potato tubers. Source: (8)

	IRRIGATED		CHECK	
	TUBER DEPTH		TUBER DEPTH	
	1-4"	6-8"	1-4"	6-8"
MEAN BLACKSPOT	1.85	1.52	2.3	1.95
SE OF BLACKSPOT MEAN	.22	.20	.24	.23
MEAN PER CENT SOIL MOISTURE	8.3	11.19	5.63	9.86
SE OF MEAN PERCENT MOISTURE	.56	.49	.50	.54
MEAN SPECIFIC GRAVITY	1.087	1.088	1.088	1.091
SE OF MEAN SPECIFIC GRAVITY	.010	.012	.013	.014

Table 2. Effect of evacuation and rehydration on the specific gravity, blackspot, and amount of water absorbed by blackspot susceptible Russet Burbank potato tubers. Source: (8)

TEST NO.		SPECIFIC GRAVITY	BLACKSPOT	GRAMS WATER ABSORBED	PERCENT INCREASE IN WEIGHT
1	START	1.0897	BAD		
	HYDRATED	1.0877	NONE	353	10.9
2	START	1.0927	BAD		
	HYDRATED	1.0910	NONE	352	11.6
3	START	1.0976	BAD		
	HYDRATED	1.0954	TRACE	238	5.7
4	START	1.0927	BAD		
	HYDRATED	1.0922	TRACE	345	10.6

Figure 1. Effect of soil CO_2 concentration on blackspot index. Source: Adapted from (21)

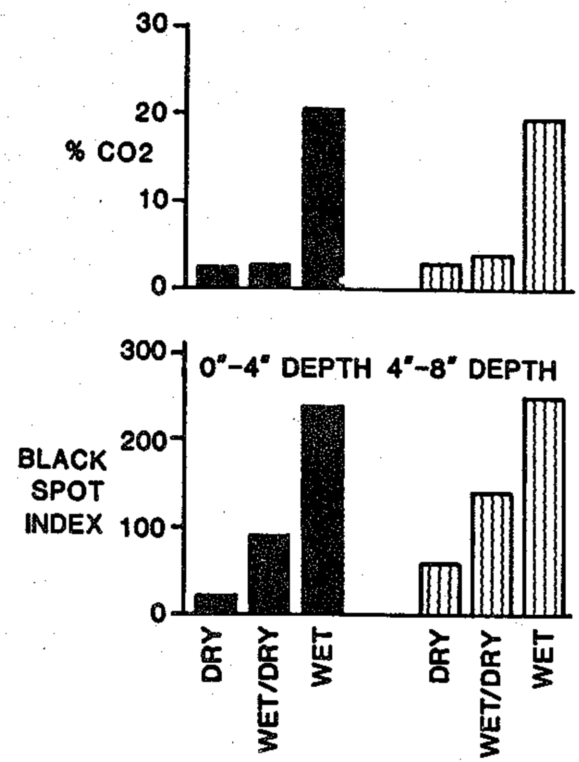

Figure 2. Effect of tuber hydration level on blackspot and shatter bruise (45-50°F). Source: (15)

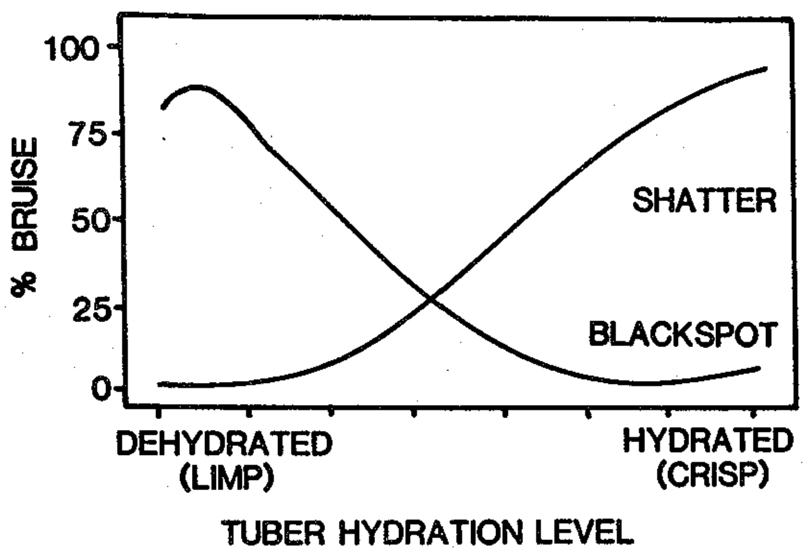

Figure 3. Effect of tuber weight changes on blackspot susceptibility. Source: (6)

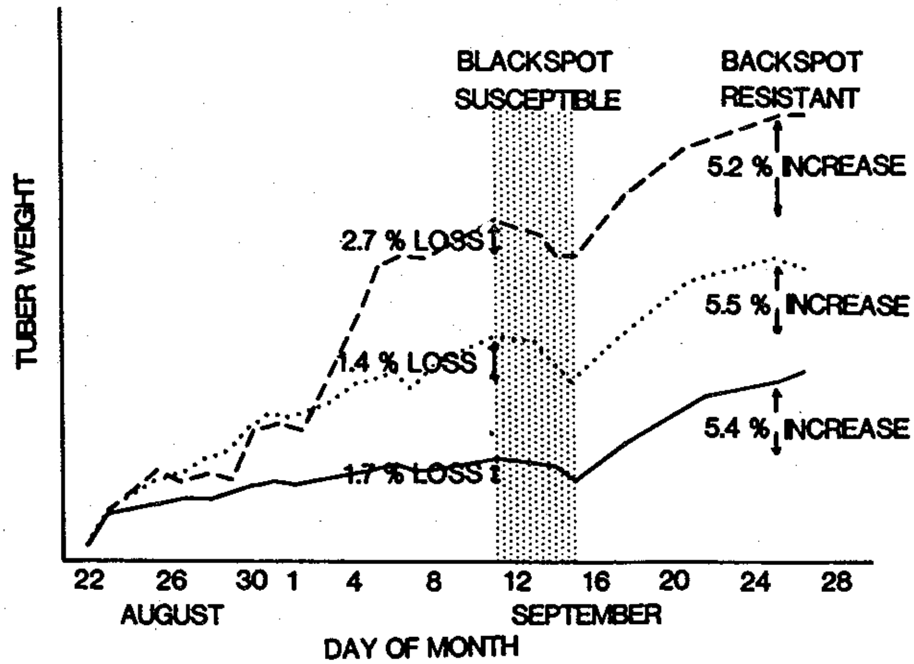

Figure 4. Effect of tuber temperature and hydration level on damage susceptibility. Source: (15)

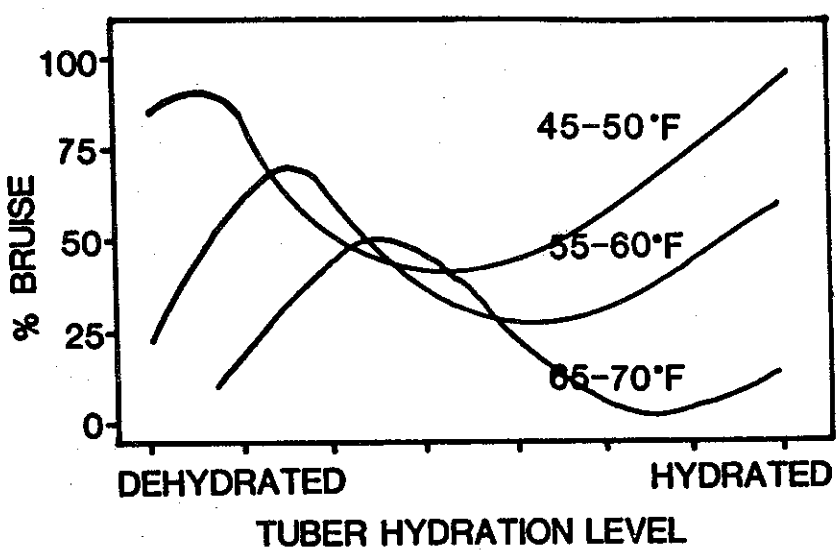

Figure 5. Effect of potassium fertilizer level on tuber specific gravity and blackspot index. Source: (9)

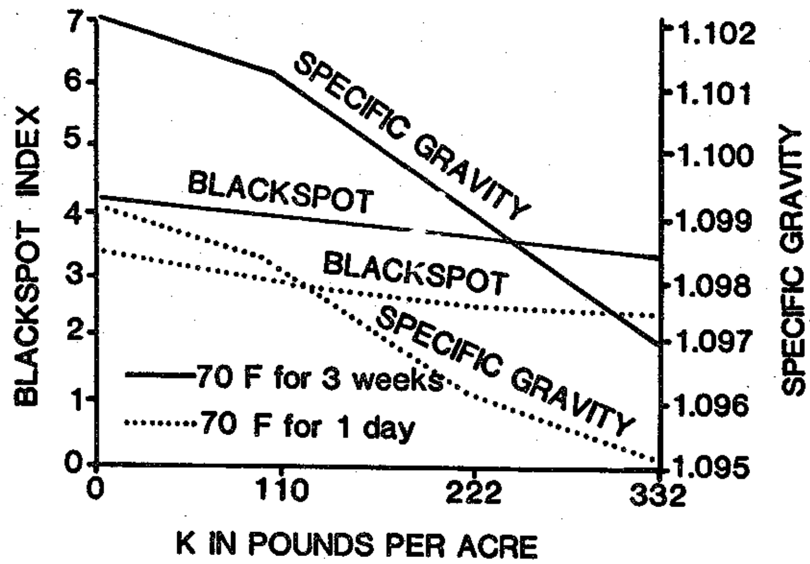

Figure 6. Effect of potassium fertilizer on blackspot of potato tubers. At 110 days irrigation was discontinued following which factors other than potassium level dominated the response. Source: Adapted from (7)

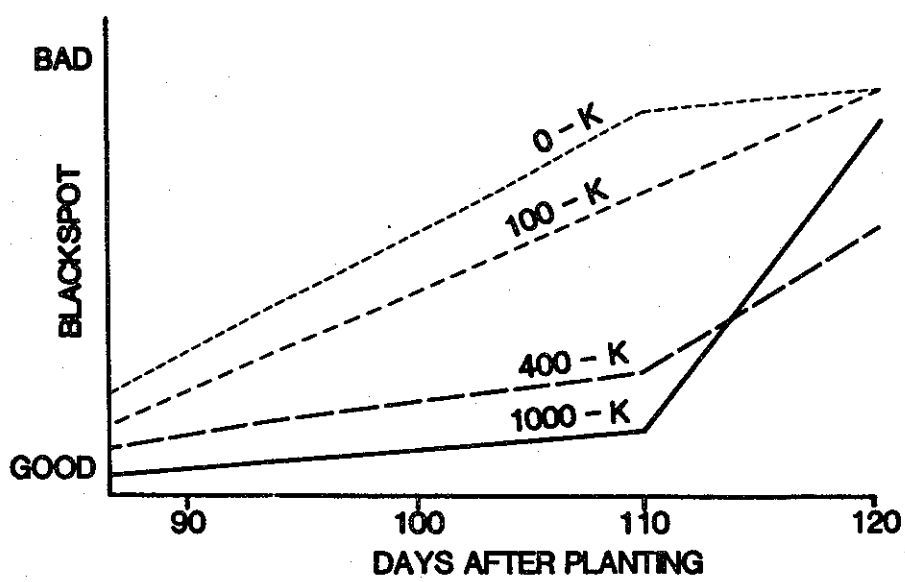

Figure 7. Effect of nitrogen fertilizer rate and soil moisture level on tuber yield and specific gravity of Russet Burbank potato tubers. Source: Adapted from (9)

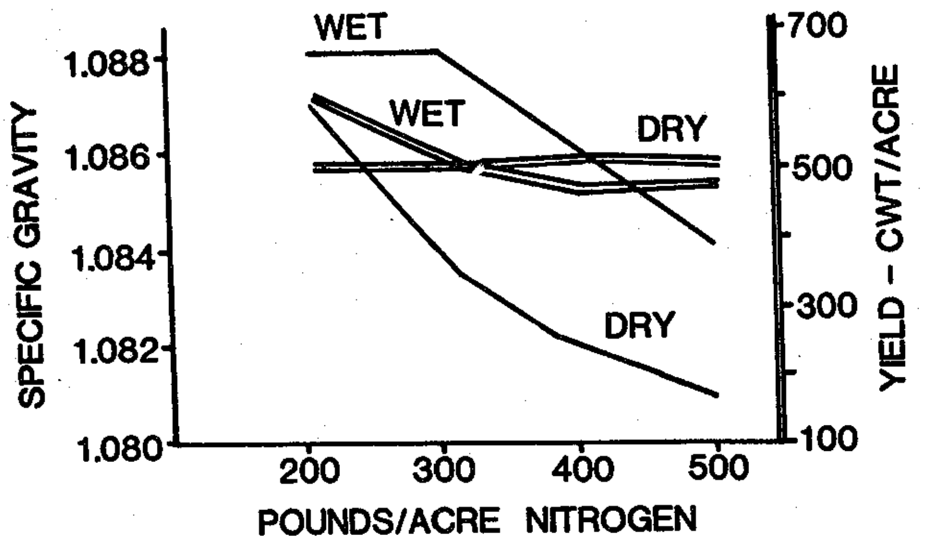

Figure 8. Effect of damage susceptibility and harvester operation on bruise. Source: (15)