UPGRADING INTERNAL POTATO QUALITY

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During the past 20 years there has been increased discussion about the blackspot problem in potato tubers. In most instances the name 'blackspot' is quite descriptive of the malady. The name emphasizes the major symptom of the malady, but if it were named "internal bruise" it would fit the situation better, because all cases of different degrees of discoloration would be covered, and in addition, emphasis would be given to the basic cause: a bruising force hard enough to injure living potato cells. That a bruise is necessary has been known from the time of the first studies which were reported in 1912. But the problem was not solved because it was soon discovered that it required a bruise plus something else, since not all tubers which were bruised developed black spots.

From 1912 until 1957, studies were conducted in an attempt to discover the factor or factors responsible for making tubers susceptible to internal bruising, (to be referred to as STIB). Many factors were found to decrease the severity of STIB, but all factors discovered exerted a modifying and not a controlling effect. At times a given treatment might increase the STIB and under different conditions the STIB might be decreased by the same treatment.

In 1957 it was learned that STIB was a relatively easily reversible condition in the laboratory and that the discoloration observed depended upon the turgor pressure (plumpness) of the cells at the time the bruise was inflicted. Turgor pressure gives a cell its mechanical strength much like the air in a tire supports the weight of the car.

In 1958 it was discovered that live potato plants actually withdrew water from the tubers if insufficient water to meet the needs of transpiration could be gotten from the soil by the roots. This is similar to the situation known for many years when leaves of fruit trees draw water from the fruit under conditions of a moisture shortage. The blackspot problem was accentuated by a grower practice related to this kind of phenomenon. Prior to 1958 it was a common practice for potato growers to stop irrigation to "set" the skins of the tubers to meet maturity regulations and thus be able to harvest sooner and take advantage of more favorable prices. It was not realized that when the water in the soil was gone the vines continued to live for a while by drawing water from the tubers, thus making them STIB.

In 1959 it was learned that root diseases can be and probably are responsible for STIB under a number of conditions. Tubers from a field where plants had green immature looking vines where the soil was wet were turning black when bruised. Vines were pulled and it was found that many of the roots were dead and non-functional even though there was no sign of wilting in the leaves.

To determine whether roots actually could be involved, a test was conducted in an experiment where the effect of wet and dry soil on STIB was under study. The soil was removed carefully from around the roots and tubers of a number of plants. All roots except about three or four at the bottoms of the stems then were cut off and the tubers were carefully re-covered with soil. About 18 hours later the leaves on the plants growing in the low soil moisture plots were showing signs of wilting. The tubers again were uncovered and each tuber was marked and bruised near the stem end while the tubers were still attached to the plant. The following morning the bruised spots were peeled and every spot on every tuber on every plant growing in the low soil moisture plot had a large brownish-black spot. Those similarly treated but growing on the high moisture plots showed no evidence of having been bruised. One big question was still unanswered - were the tubers STIB before the test was begun?

In 1960 it was intended to emphasize root pruning and soil moisture studies, but in two fertilizer experiments those treatments which did not include potash had developed a deep green color and the tissue between the veins of the leaves was beginning to show small patches of dark brown dead tissue. By this time the plants were 100 days old. Within three weeks after the potash deficiency symptoms were observed the plants were dead. Plants in those plots which received as little as one hundred pounds per acre of K_2O were still green and showed none of the symptoms observed on the no-potash plots. After having seen actual potash deficiency symptoms, relatively large areas and unnumbered small areas were found which displayed similar symptoms. That potash deficiencies actually were involved is supported by soil and tissue tests and yields response from applications of potash.

Tubers dug from three potash deficient areas were extremely STIB, but could be made nearly 100 per cent resistant within 24 hours in the laboratory by rehydration. Root systems of these plants, carefully washed out with a small jet of water were observed to be poorly developed and to have a paucity of root hairs. Well developed root systems with plenty of root hairs, necessary for absorption of both water and nutrients, are found where potash is not deficient. It would appear that one of the primary functions of potash is to stimulate root development. This would have a marked effect upon the maintenance of turgor in tubers where the plants are subjected to water stress conditions. Potash can also affect the resistance of tuber tissue to loss of water. When cores of tissue cut from tubers grown on deficient and high-level potash soils were subjected to desiccation in a series of concentrations of sucrose solution, it was found that the tuber tissue from the potash deficient soils turned black quicker and developed a more intense pigmentation than cores cut from tubers grown with adequate potash. Of all the major and minor mineral elements believed to be essential for plant growth, potash is the only one which has consistently reduced, but not eliminated, STIB in both the United States and Europe.

In 1961, potash deficiency was definitely associated with the tendency of low-potash plants to wilt and develop leaf scorch on extremely hot days, with premature dying of plants, and with the tendency for tubers to be STIB. Growers who know that they have cut areas might find it profitable to have a soil sample taken from those areas. Should the test be medium to low in phosphorus and/or potash, these areas could receive supplemental applications of those elements in addition to the regular fertilizer. If there are many areas in a field where plants tend to die prematurely, a uniform application of 80 to 160 pounds per acre of P_2O_5 and 100 to 150 pounds per acre of K_2O along with nitrogen probably would increase yield and reduce STIB. There is some recent evidence that on some crops (not potatoes), low levels of potash in the soil are associated with the severity of root rots.

Further evidence of the close relationship between water and STIB has come from an experiment where potato tubers were weighed in the field while still attached to the plant and in growing condition. This experiment shows weight losses during conditions of high temperature and low humidity and also shows the effect of a damaged root system on the water supply to the plant and particularly to potato tubers.

In this experiment the tubers of a healthy appearing hill of potatoes with three stems were carefully uncovered. The stems were securely tied to stakes, and a balance was attached to each of the four tubers in the hill. Two stems each had a single tuber and the third stem had two tubers. In order to get the tubers to swing freely it was necessary to remove a few of the roots. However, most of the roots were left virtually undisturbed. After the set-up was complete, black plastic was used to exclude light and maintain a higher humidity around the tuber in the excavation than that of the air outside. The tubers then were weighed periodically. The soil moisture was near field capacity as measured by "Irrometers."

The tubers were excavated on August 22, and August 23 was an extremely hot day (102° F.). Three of the tubers lost considerable weight this day, and it required several days before they approached their original weight. The tuber closest to the transpiring leaves, No. 1, lost considerable weight, whereas the tuber only a few inches closer to the roots, No. 2, lost essentially no weight after an initial loss which was probably the result of disturbance during preparation for weighing. The two tubers on the same stem responded very differently to transpirational moisture stress; this fact could be a clue as to why tubers from the same hill differ so markedly in STIB.

By September 6 both tubers No. 1 and No. 2 were larger than when the experiment was started on August 23. On September 6, all the roots on the stem to which tubers 1 and 2 were attached were cut off, but the tubers were left attached to the stems. Each tuber was marked and bruised near the stem end at 12 o'clock noon. By noon of September 8, the leaves were dead and the stem extremely wrinkled. Tuber No. 1 had lost 6 per cent of its weight and tuber No. 2 which was lower on the stem had lost 3 per cent of its weight. The tubers were marked again and bruised close to the spots which were bruised on September 6. Twenty-four hours after bruising the bruised areas were peeled. Those areas bruised on September 6 when the tubers were turgid were unaffected but after the roots were cut and the tubers had lost water they were completely susceptible to blackspot.

The differences of 3 and 6 per cent may not seem large but it must be emphasized that 3 per cent of a 400 gram tuber represents a loss of 12 grams of water, (about the same as losing $\frac{1}{2}$ ounce from a 1 pound tuber). This came mostly from the stem end, which became soft, while the bud end was still hard to the touch. This observation suggests a reason why STIB usually is greatest at the stem end. However, in storage, tubers as much as 12 inches long have been found which were as susceptible at one end as at the other. This is easily understandable, because with time a moisture equilibrium may be established.

High specific gravity within a variety has been associated with STIB, but in this test tuber No. 1 had a specific gravity of 1.078 and tuber No. 2 had a specific gravity of 1.071 and both tubers were about equally susceptible. It would appear that STIB is not uniquely associated with specific gravity, which is in agreement with other measurements made in this laboratory on thousands of individual tubers.

One additional finding of importance relative to temperature dependence of STIB may be pointed out from this experiment. When tubers are removed from storage and warmed up they usually are found to be less STIB than the cold tubers. In this experiment the tubers were nearly at air temperature in the field, which in this case was quite warm, yet the dehydrated tubers were highly STIB.

These findings probably are the best explanation why in areas of high summer temperature and low humidity, STIB is a field problem, and why in Eastern and European areas where temperatures are not as high and the relative humidity seldom goes below 60 per cent, STIB is essentially a storage problem. However, STIB can be both a field or a storage problem in any area if conditions are favorable to the loss of moisture from the tubers.