RESUME OF BLACKSPOT

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Summary:

Many seemingly contradictory results of research on blackspot occur in the literature. All of the factors shown to influence blackspot can be related back in some way to tuber hydration. By adjusting cell turgor, tubers can be made either susceptible or resistant to blackspot and the effect on blackspot is reversible in the field and in the laboratory. Tubers which have become susceptible in the field remain susceptible in storage. Tubers which are resistant in the field can become blackspot susceptible in storage by loss of moisture. The effects of turgor pressure are often confounded by changes in tuber flesh temperature which affects the flexibility of the tissue. The time required to change blackspot susceptibility in the field or in storage is considerably longer than formerly recognized. Weeks rather than days are involved.

Of the major and minor elements only high levels of potassium consistently reduce blackspot but often fail to give commercial control. Keeping the soil moist will not reduce blackspot in the field if potassium is not adequately available to the plant. There are many small spots in most potato fields which are potassium deficient and which are two small to treat separately. If plants are green and vigorous at the time the vines are killed, and the soil is moist, the tubers are likely to be resistant to blackspot and have other beneficial effects. It has long been known that potatoes from late plantings, the vines of which are killed by frost when the soil is moist, are highly resistant to blackspot.

There are still occasional lots of potatoes which are blackspot susceptible for which an adequate explanation is lacking or for which accurate background information is not available.

Basic to the whole problem of blackspot is careful handling, proper growing of the potatoes and high humidity in storage.

Introduction:

Blackspot has been variously called - internal bruise, stem end blackening and pressure bruise - in the United State and denoted by similar connotations throughout Europe; but there is good reason to believe it is the same problem throughout.

The first written blackspot report was published in England in 1912. Between 1912 and 1936 eleven reports on the subject were published in Europe. By 1936 the association between a bruising force and blackspot,

potassium deficiency and blackspot, high specific gravity and blackspot, varietal differences, and failure to associate a causal organism with blackspot were documented.

The first written blackspot reports in the United States were published in 1940. Several reports referred to the blackspot problem on Long Island, New York. The first written blackspot report relating to the problem in Washington was published in 1944. Since that time blackspot has been reported from all the major potato producing areas throughout Europe, the United States and Canada.

Between 1936 and 1957 some 31 blackspot reports were published in Europe and America. In all these reports, blackspot was referred to primarily as a storage problem with only an occasional reference to blackspot as a field problem.

Studies in the United State have verified the findings in Europe that bruising, low potash levels in the soil, high specific gravity in the potatoes and variety were definitely part of the blackspot problem. In addition, it was found that nitrogen levels, phosphorus levels, and tuber flesh temperature could at times be contributing factors. But the basic problem still remained because high levels of potassium, careful handling and warming up the tubers only reduced but did not eliminate the problem.

Between 1957 and 1970 a total of 22 blackspot reports were published in the United States and Canada. Of these reports, 12 originated in Washington or California - both states are heavy shippers of summer and early fall potatoes wherein maturity regulations governing the amount of allowable skinning are in effect. "Maturity" (skin setting) is usually accomplished by limiting the nitrogen and/or turning off the irrigation water and vine killing. If overdone, potatoes become blackspot susceptible.

Studies on blackspot in Washington, under the sponsorship of the Washington State Potato Commission, began the spring of 1957. Lest one forget the services of the Commission and fail to appreciate the progress which has been made during the last 12 years a short backward glance in time may be worthwhile.

In 1957 Washington potatoes were discriminated against in the markets because of blackspot. By repute they would not "store" and such storages as did exist were being converted for other purposes, allowed to deteriorate, or remain vacant. Potassium deficiency in the Basin was unknown. The average yield was 300 cwt/acre. Idaho processors' attempts to process Columbia Basin potatoes were discouraging. Growers were afraid to use, and chippers and fryers of potatoes discouraged the use of

more than 100-125 lb/acre of N for fear of reducing the grade-out and also the processing quality. There was essentially no potato processing. All this is changing and even greater things can be anticipated; Washington ranked 6th in total potato production but is now 3rd and pushing 2nd place.

Results in Washington and New York indicate degrees of tuber hydration-turgor pressure-is a basic factor in causing potatoes to become blackspot susceptible. Observational reports from this and other areas that "blackspot increases as maturity increases" lead to the same conclusions. What is really meant when it is said potato plants are maturing is that the leaves are turning yellow and, in short, the plant is dying. Another recorded comment is that if the bruised area cracks there is no blackspot. In essence, only turgid tissue "cracks". There is ample evidence that blackspot susceptible tissue if cold (40° F.) both cracks and turns black. Thus it becomes a problem of knowing when potatoes are turgid. Unfortunately, there is no easy method for measuring it.

Blackspot susceptibility is a reversible condition and it can be done by adjusting the water content of the tissue. A change in temperature may complicate the results because of its effect on tuber flexibility.

Experimental Procedure:

1. Samples were gathered from potato fields wherein the potatoes were known to be badly blackspot susceptible. The samples were taken into the laboratory and held for 24 hours to bring the potatoes to 70° F temperature. Thereafter, sample lots were tested for blackspot and others were hydrated by placing them in 70-75° F. water in a vacuum chamber. Suction was applied for 10 minutes. The tubers soaked for 24 hours and were then tested for blackspot. The results are shown in Table 1.

The results from only four tests are shown. In these tests, increasing the weight about 10% using water decreased the blackspot from severe to nil. Increasing the water content of the potatoes decreased the specific gravity by about .002 making the potatoes more suitable for the fresh market but less suitable for the processors. The extra water would have to be evaporated thereby increasing the cost of processing. A processor can use blackspot susceptible potatoes if they are processed within about 10 hours after bruising. Usually it requires 18 or more hours for the full development of the black color.

Table 1. Effect of evacuation and rehydration on the specific gravity, blackspot, and amount of water absorbed by blackspot susceptible Russet Burbank potato tubers.

Test No.	SPECIFIC GRAVITY	BLACKSPOT	GRAMS WATER ABSORBED	% INCREASE IN WEIGHT
1. Start	1.0897	Very bad		
Hydrated	1.0877	None	353	10.9
2. Start	1.0927	Bad		
Hydrated	1.0910	None	352	11.6
3. Start	1.0976	Very bad		
Hydrated	1.0954	Trace	236	5.7
4. Start	1.0927	Very bad		
Hydrated	1.0922	Trace	345	10.6

In 1968, three experiments were conducted to determine the effect of fertilizer levels on blackspot of different potato varieties when fertilized for a given time of harvest. The fertilizer rates used were based on the results of previous experiments with the Russet Burbank variety and are based on the intended harvest period. These experiments were side by side on land with the same cropping history. Each treatment was replicated six times. The plots were 2 rows wide and 28.5 feet long.

In experiment 1, five varieties - Russet Burbank, Kennebec, White Rose, Norgold Russet and Cascade - were planted on April 4, harvested on August 6, and blackspot testing began August 13. Each variety was grown on four fertilizer rates - 50, 100, 150 and 200 lbs. of N, P_2O_5 and K_2O/acre derived from a 16-16-16 fertilizer.

In experiment 2, the five above mentioned varieties were planted April 5, harvested September 6, and blackspot testing began September 9. The four fertilizer rates - 75, 150, 225, and 300 lbs. of N, P_2O_5 and K_2O/acre derived from 16-16-16 fertilizer - were higher than for the August harvest because the growing season was a month longer.

In experiment 3, the varieties were planted April 8, harvested October 9, and blackspot testing began October 15. The four fertilizer treatments were 100, 200, 300 and 400 lbs. of N, P_2O_5 and K_2O/acre also derived from a 16-16-16 fertilizer. These rates were the highest because the growing season was the longest.

In the first two experiments irrigation was continued until two or three days prior to beating off the vines and the potatoes were dug the following day.

The final irrigation of the third experiment was about the last week of September.

In Table 2, by comparing the means in the right hand column for the three harvest periods, it can be seen that within each harvest date fertilizer rate caused only a minor difference in blackspot. By comparing the general means for varieties at the bottom of the three experiments, it can be seen that only minor differences existed among the five varieties in blackspot. The White Rose variety was slightly more resistant. A more detailed study of the varietal differences within harvest periods indicate varietal differences exist but the differences were not significant statistically.

By comparing the harvest period means (bottom figure in right hand column for each harvest) it can be seen that there are no differences in blackspot between potatoes harvested 124 and 154 days after planting. After 184 days from planting there was a minor increase in blackspot. A reflectometer value of 80 and over in tuber flesh reflectance is without blackspot. A value of 70 is a grayish, small perceptible spot.

On the first two harvest dates the vines were not dead even at the lowest rates of fertilization. They had, however, died sometime prior to the October harvest date. The death of the vines, the lower temperatures in October, and the lapse of time between harvest and testing for blackspot could explain the minor differences found in blackspot even though the soil was kept moist.

The implications of these findings are great because they demonstrate that increased "maturity" does not always result in increased blackspot if the soil is kept moist and the plants are kept alive close to the time of harvest. Unfortunately, the potatoes from the first and second harvest could not have passed maturity regulations because of skinning.

The 1969 studies were facsimilies of the 1968 experiments with the exception that there were two harvest dates within each harvest period and irrigation was stopped 7 days prior to beating off the vines. The objectives were to reproduce the 1968 results and to obtain data on the time required to "set" the skin.

Table 2. Results of the 1968 fertilizer rate, variety and harvest date experiment. (Higher number, less blackspot - over 80, no blackspot)

Table 2a. Blackspot of potatoes harvested August 6, 124 days after planting.

Pounds per Acre N	P_2O_5	K_2O	Russet Burbank	Kennebec	White Rose	Norgold Russet	Cascade	Mean
50	50	50	75	78	82	75	80	78
100	100	100	78	79	82	76	80	79
150	150	150	80	78	81	73	80	78
200	200	200	79	77	81	74	79	78
	Mean		78	78	82	75	80	78

Table 2b. Blackspot of potatoes harvested September 6, 154 days after planting.

75	75	75	74	79	85	78	80	79
150	150	150	74	83	84	79	80	80
225	225	225	74	80	84	75	78	78
300	300	300	74	80	82	77	72	77
	Mean		74	81	84	77	78	79

Table 2c. Blackspot of potatoes harvested October 9, 184 days after planting.

100	100	100	63	69	82	69	76	72
200	200	200	68	72	81	73	67	72
300	300	300	66	73	75	66	67	69
400	400	400	65	72	78	69	65	70
	Mean		66	72	79	69	69	71
General Mean			73	77	82	74	76	76

Stopping irrigation seven days prior to beating off the vines was done for the following reason: the water holding capacity of the soil was about 2.56 acre inches/foot of soil, making a total of 5.10 acre inches of water in the top two feet of soil. Plants could use 2.56 acre inches of water and thereby reduce the water in the soil to 50% of field capacity and this should not stress the plant to the extent that the tubers would become dehydrated. On an average, water is lost through the plant and evaporated from the soil at the rate of about .35 acre inches/day. Thus 2.56 acre inches of water per .35 acre inches lost per day equals seven days supply of water.

In experiment 1, the seed was planted April 11, irrigation was stopped July 7, the vines were beaten off July 14, half of each plot was harvested July 15, and the potatoes were tested for blackspot July 17-23. The second half of each plot was harvested July 28 and the potatoes tested for blackspot July 31 to August 6. The potatoes were rated on a 0-10 scale for skin scuffed off during harvesting, grading and handling. Zero, on the scale, was no skin loss and 10 was 100% skin loss.

In experiment 2, the seed was planted April 11, irrigation was stopped August 28, the vines were beaten off September 2, half of each plot was harvested September 4, and blackspot was determined September 5-10. The second half of each plot was harvested September 15 and blackspot was determined September 18-24. Skinning was scored on a 0-10 scale.

In experiment 3, the seed was planted April 12, irrigation was stopped the third week of September, the vines were beaten off October 14, half of each plot was harvested October 15 and blackspot was determined December 23-24. The second half of each plot was harvested October 27 and blackspot is still to be determined.

Only the results of the first two experiments are presented because the data for the third experiment are not completed.

In experiment 1 (Table 3a), there were statistically significant differences in blackspot among the varieties but the differences are so small they are of no commercial significance. Reflectometer values of 80 or greater indicate the flesh color without blackspot. A reflectometer value of 70 indicates a small, grayish, perceptible spot.

The potatoes harvested the day after vine beating would not have passed maturity regulations but 14 days later the skins were "set" sufficiently to withstand mechanical harvesting and there was no increase in blackspot during the interum. Fertilization at the levels used did not affect blackspot.

In experiment 2 (Table 3b), in which the potatoes were harvested September 4 and 15, there were very highly significant statistical differences among the varieties but the differences were small. On both harvest

dates, Russet Burbank, Norgold Russet and Cascade had almost identical reflectometer readings. As found in previous years when fertilizers begin to run out, there is a tendency for the potatoes to show more blackspot at low fertility levels. The effect is not large but it is highly significant statistically.

Table 3. Results of the 1969 fertilizer rate, variety and harvest date experiment. (Higher number, less blackspot - over 80, no blackspot)

Table 3a. Vines beaten off 93 days after planting, potatoes harvested July 15.

Pounds per Acre N	P_2O_5	K_2O	Russet Burbank	Kennebec	White Rose	Norgold Russet	Cascade	Mean
50	50	50	82	81	82	79	78	80
100	100	100	82	81	84	77	77	80
150	150	150	81	80	79	77	78	79
200	200	200	80	80	81	76	78	79
	Mean		81	81	82	77	78	80
			Vines beaten off 93 days after planting, potatoes harvested July 28.					
50	50	50	75	81	82	79	78	79
100	100	100	77	79	84	79	76	79
150	150	150	80	80	82	75	81	80
200	200	200	79	82	84	76	78	80
	Mean		78	81	83	77	78	80

Table 3b. Vines beaten off 145 days after planting, potatoes harvested Sept. 4.

75	75	75	65	75	76	61	65	68
150	150	150	69	78	77	67	67	72
225	225	225	60	76	78	65	71	70
300	300	300	69	81	80	68	69	73
	Mean		66	78	78	65	68	71

Vines beaten off 145 days after planting, potatoes harvested Sept. 15.

Table 3b continued.

Pounds per Acre N	P_2O_5	K_2O	Russet Burbank	Kennebec	White Rose	Norgold Russet	Cascade	Mean
75	75	75	68	66	76	63	70	69
150	150	150	68	76	79	64	68	71
225	225	225	67	77	79	66	67	71
300	300	300	67	79	80	69	68	73
Mean			68	75	79	66	68	71

The potatoes harvested September 4, the day after vine beating, would not have passed maturity regulations but those harvested September 15 would have passed. Undercutting was not used in either experiment one or two.

In both the 1968 and the 1969 studies there is evidence of increased blackspot with increased age of plants, expecially with some varieties.

Potato Combine Experiment:

An experiment was designed to determine the relationship between our laboratory method of testing for blackspot and the amount of blackspot occurring during machanical harvesting. It was found that if by the laboratory method potatoes were resistant to blackspot, they were also resistant to blackspot when harvested by a potato combine. In addition, blackspot resisant potatoes were also resistant to mechanical bruising and the cuts and bruises occurring during harvesting healed over quicker and at lower humidities than was the case with blackspot susceptible potatoes.

The combine test was severe. The shakers bounced the potatoes 6-8 inches high and they were dropped 3-4 feet into a bulk potato bed. The results indicate that the laboratory method of testing for blackspot is more severe than potatoes should ever encounter during the normal harvesting operation.