# RELATIVE RESISTANCE OF THE POTATO CULTIVAR KRANTZ TO COMMON SCAB CAUSED BY *STREPTOMYCES SCABIES* AS DETERMINED BY CLUSTER ANALYSIS

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**Abstract**

Twenty potato breeding selections and five potato cultivars (25 clones) were evaluated in replicated field plots for their resistance to common scab caused by *Streptomyces scabies*, at Presque Isle, ME and Cranesville, WV in 1993. At harvest, all tubers in each plot were individually scored for the surface area covered (0=0% to 5>75%) and for lesion type (0=no lesions to 5=pitted lesions). The individual tuber scores for either surface area covered or lesion type for each plot were totaled and divided by five times the number of tubers to create an index of surface area covered (SAI) or lesion type (LI), respectively. Clonal mean SAI ranged from 0.05 to 0.96 in Maine and 0.21 to 0.89 in West Virginia. Clonal mean LI ranged from 0.06 to 1.0 in Maine and 0.48 to 1.0 in West Virginia. There were significant differences among clones for SAI and LI. Clones were clustered on mean SAI and LI in ME and WV. The clones clustered into four groups. The resistance of Krantz and two breeding selections, B0348-2 and B0339-1, was similar to Ontario.

**Compendio**

Veinte selecciones de mejoramiento de papa y cinco cultivares (25 clones) fueron evaluados, en 1993, en parcelas de campo con repeticiones, para su resistencia a la sarna común causada por *Streptomyces scabies*, en Presque Isle, ME y Cranesville, WV. Al momento de la cosecha, todos los tubérculos en cada parcela fueron calificados individualmente por el área de superficie cubierta (0=0 % a 5>75 %) y por el tipo de lesión (0=sin lesiones a 5=lesiones profundas). Las calificaciones individuales por tubérculo, tanto por área de superficie cubierta como por el tipo de lesiones, para cada parcela, fue totalizada y dividida por cinco veces el número de tubérculos, para crear un índice de área de superficie cubierta (SAI) o de

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tipo de lesión (LI), respectivamente. El promedio clonal del SAI varió de 0.05 a 0.96 en Maine, y de 0.21 a 0.89 en West Virginia. El promedio clonal del LI varió de 0.06 a 1.0 en Maine, y de 0.48 a 1.0 en West Virginia. Hubo diferencias significativas entre los clones, para SAI y LI. Los clones fueron agrupados de acuerdo al promedio de SAI y LI en ME y WV. Los clones se agruparon en cuatro grupos. La resistencia de Krantz y dos selecciones de mejoramiento, B0348-2 y B0339-1, fue similar a la de Ontario.

## Introduction

Common scab, caused by the actinomycete, *Streptomyces scabies* (Thaxter 1891) Lambert and Loria 1989 (9) is a disease that occurs on all underground parts of the potato (*Solanum tuberosum* L.) (12). No potato cultivar is immune to infection by *S. scabies*, but there is considerable variation in cultivar response (12). Surface lesions and pitting are the two most common tuber symptoms of this disease. The extent of the surface lesions may range from a superficial cork-like layer (russet scab) to an erumpent raised corky area (raised scab). Pitted scab lesions are dark brown to black pits of varying depths and diameter surrounded by straw colored translucent tissue. A tuber can have lesions of both types. Lesions can be discrete and singular or they can coalesce and completely cover the tuber surface (2, 3, 12, 15).

Reactions of respective cultivars to infection by *S. scabies* are evaluated either qualitatively or quantitatively. A qualitative evaluation consists of growing a cultivar in soil infested with pathogenic strains of the organism and visually comparing the type and amount of scab with that present on cultivars with known degrees of scab resistance. Numerical systems of scoring symptom severity are used to make a quantitative comparison of cultivars for their reaction to *S. scabies*. Such systems are based either on the proportion of tuber surface covered or on the type of lesion. Because there is a correlation between the lesion type and tuber surface area covered with lesions (1, 2, 11), either criterion could be used to estimate the relative scab reaction of cultivars. Recently cluster analysis (14) based on a combination of surface area covered and lesion type has been used to categorize breeding selections and cultivars into scab reaction groups (6).

In this study we used cluster analysis (14) to evaluate twenty potato breeding selections and five cultivars for their reaction to scab in field trials at two locations.

## Materials and Methods

### *Inoculum*

A modification of the puncture method of Goth (4) was used to isolate *S. scabies* from symptomatic tubers. A heat-sterilized needle was inserted

into the translucent tissue immediately below the pitted scab lesion, and a tissue section was transferred to water agar (1.5% Difco agar). Because production of melanin on tyrosine-containing media is a distinguishing characteristic for selecting pathogenic isolates of *S. scabies* (5, 8), *Streptomyces* colonies were visually selected from typical bacterial colonies and transferred to Okanishi's R-2 Regeneration Media (R-2) containing 0.1% tyrosine (13). Strains that produced melanin were evaluated for pathogenicity on radish (*Raphanus sativus* L) cv Cherry Belle. Those strains that produced scab lesions on radish were increased on R-2 medium and used for inoculum in field studies. To increase the pathotype diversity of the inoculum, peels from tubers with surface and/or pitted scab lesions were used to compliment the strains grown on the R-2 medium. Care was taken to remove only the scab lesion and a minimum of adjacent tissue. Peels were dried at 22-24 C for 72 hr and ground dry with a vita-mix food processor. Inoculum was a mixture of R-2 medium with seven melanin-producing isolates of *S. scabies,* the dried scab tissue, and distilled water mixed at a 1:1:1 ratio by volume. The mixture was comminuted with a Waring blender for 10 minutes. The resultant mixture was plated on the R-2 media and contained $3x10^7$ cfu/ml of melanin-forming colonies of *S. scabies.*

Twenty advanced breeding selections from the USDA/ARS potato breeding program were tested in this study to determine their level of scab resistance prior to possible release. Four of the five cultivars included in the test as standards were chosen because their reaction to scab is known. Green Mountain is scab susceptible; Russet Burbank and Superior are scab tolerant; and, Ontario is scab resistant (6, 11). A recently released cultivar, Krantz (10), was included because preliminary observations suggested it was resistant (F. Lauer, personal communication).

Seed tubers of cultivars and breeding selections used in this study at both locations were obtained from virus-tested seed stock grown at both Chapman Farms and Aroostook Farm at Presque Isle, Maine.

*Field Plots*

The experiment was conducted at Aroostook State Farm, Presque Isle, ME and the Gross Farm at Cranesville, WV in 1993. Both sites had a history of common scab. The statistical design was a randomized complete block with four replications of five-hill plots in ME and five replications of four-hill plots in WV.

The soil at the Presque Isle location is a Caribou silt loam, to which 8.5 metric t/ha of composted cow manure were applied in both 1990 and 1991. Just prior to planting in 1993, the pH was adjusted to 6.7 with dolomitic lime. The between and the within row spacings were 92 and 32 cm. Each seed piece was cut, drenched with 50 ml of inoculum and immediately covered with soil. Vines were killed 90 days after planting and tubers were harvested and individually scored within 30 days of vine kill.

TABLE 1.—*Analysis of variance for LI[1] and SAI[2] for 25 potato clones evaluated in Maine and West Virginia in 1993.*

| Source | d.f. | M.S. L.I. | M.S. SAI |
|---|---|---|---|
| Locations | 1 | 1.87** | 0.00 |
| Rep (Locations) | 7 | 0.05** | 0.29** |
| Clones | 24 | 0.31** | 0.36** |
| Clones * Locations | 24 | 0.07** | 0.06** |
| Error | 164 | 0.02 | 0.02 |
| Total | 220 | | |

[1]Lesion index (LI) was calculated as LI=$\sum_{i=1}^{n}$(lesion severity)/[5(number of tubers)].
[2]Surface area infected index (SAI) was calculated as SAI=$\sum_{i=1}^{n}$(surface area infected)/[5(number of tubers).
**Significant at the 1% level.

The soil at the Cranesville, WV location is a climer loam into which composted manure at 8 t/ha and hydrated lime to adjust the pH to 6.0 were incorporated by discing just prior to planting. The between and within row spacings were 136 and 26 cm, respectively. Well suberized seed pieces with eyes oriented up were hand planted. The inoculum at this location was the population of *S. scabies* present in the soil.

*Scoring*

Every tuber in the plots was examined, and the percentage surface area with scab lesions was estimated using a 0-5 scale where 0=none; l=l-l0%; 2=l0-25%; 3=25-50%; 4=50-75%; and 5=76-100% of the surface area covered. Lesion type was based on those used in the assessment key of James (7) where 0=no scab; 1=superficial lesions less than 10mm diameter; 2=superficial lesions greater than 10mm in diameter; 3=raised lesions less than 10mm in diameter; 4=raised lesions greater than 10mm in diameter; and 5=pitted scab of all diameters. When tubers had multiple lesions, the most severe lesion type was assigned.

LI and SAI were calculated for each 4-5 hill plot as the sum of the individual lesion rating or surface area covered ratings respectively, divided by 5 times the number of tubers. For each location, a clonal mean LI and SAI was calculated. The unweighted pair-group method using arithmetic averages was used to cluster the clones (14) on clonal mean LI and SAI for both locations.

TABLE 2.—*Response of potato clones to common scab in Maine and West Virginia in 1993. Average lesion index (LI)*[1], *average surface area infected index (SAI)*[2], *and respective cluster for 25 potato clones.*

| | LI | | SAI | | Cluster[3] |
|---|---|---|---|---|---|
| Clone | Maine | WVa | Maine | WVa | |
| BO178-34 | 0.96 | 1.00 | 0.82 | 0.76 | 4 |
| BO257-12 | 0.94 | 1.00 | 0.96 | 0.79 | 4 |
| BO257-3 | 0.97 | 0.99 | 0.83 | 0.71 | 4 |
| BO257-9 | 0.86 | 1.00 | 0.61 | 0.80 | 3 |
| BO306-6 | 0.87 | 1.00 | 0.85 | 0.80 | 4 |
| BO311-2 | 0.86 | 1.00 | 0.61 | 0.67 | 3 |
| BO312-10 | 0.81 | 1.00 | 0.90 | 0.85 | 4 |
| BO324-25 | 0.75 | 0.97 | 0.71 | 0.69 | 3 |
| BO329-1 | 0.78 | 1.00 | 0.71 | 0.74 | 3 |
| BO339-1 | 0.32 | 0.48 | 0.31 | 0.49 | 1 |
| BO348-2 | 0.19 | 0.74 | 0.21 | 0.42 | 1 |
| BO362-2 | 0.67 | 1.00 | 0.55 | 0.88 | 3 |
| BO427-7 | 0.84 | 1.00 | 0.69 | 0.68 | 3 |
| BO455-8 | 0.87 | 1.00 | 0.74 | 0.89 | 3 |
| BO493-8 | 1.00 | 1.00 | 0.92 | 0.87 | 4 |
| BO615-2 | 0.53 | 0.78 | 0.60 | 0.34 | 2 |
| BO616-1 | 0.78 | 0.79 | 0.63 | 0.70 | 3 |
| BO809-10 | 0.79 | 0.99 | 0.62 | 0.72 | 3 |
| BO813-7 | 0.99 | 1.00 | 0.89 | 0.82 | 4 |
| B9922-11 | 0.75 | 0.59 | 0.76 | 0.39 | 2 |
| Green Mountain | 0.81 | 1.00 | 0.87 | 0.73 | 4 |
| Krantz | 0.06 | 0.65 | 0.05 | 0.21 | 1 |
| Ontario | 0.26 | 0.78 | 0.23 | 0.42 | 1 |
| Russet Burbank | 0.72 | 1.00 | 0.62 | 0.63 | 3 |
| Superior | 0.64 | 0.98 | 0.47 | 0.38 | 2 |

[1]Lesion index (LI) was calculated as $LI=\sum_{i=1}^{n}$ (lesion severity)/[5(number of tubers].
[2]Surface area infected index (SAI) was calculated as $SAI=\sum_{i=1}^{n}$ (surface area infected)/[5(number of tubers).
[3]Based on cluster analysis using the unweighted pair-group method.

## Results and Discussion

There were significant differences between ME and WV for LI but not for SAI (Table 1). Overall, mean LI was more severe in WV (LI=0.91) than in ME (LI=0.72). Nearly all of the lesions in WV were of the deeply pitted type, whereas, raised lesions occurred more frequently in ME than in WV. These differences in lesion type between locations may be due to interactions between the inoculum, residential populations of *S. scabies* and the environment. Replications within environments were also significant sources

of variation for both LI and SAI (Table 1) indicating that there was a great deal of variation in the fields for these two indices.

There were also significant differences among clones for LI and SAI (Table 1). LI ranged from 0.06 to 1.00 in ME and 0.48 to 1.00 in WV (Table 2). SAI ranged from 0.05 to 0.96 in ME and 0.21 to 0.89 in WV (Table 2).

Clones were clustered into four groups. Nine breeding selections clustered in a group with Russet Burbank; two breeding selections clustered in a group with Superior; seven breeding selections clustered in a group with Green Mountain; and, two breeding selections and Krantz clustered in a group with Ontario (Table 2). The Ontario cluster consisted of the most scab resistant clones, as expected. Krantz had the lowest SAI of the four clones within this group in both ME and WV. In WV, LI was less for one of the two breeding selections than for Krantz in the Ontario cluster. The clones that clustered into separate groups around Russet Burbank and Superior were separated by both SAI and LI, with differences in SAI just slightly greater than differences in LI. Under these conditions, the clones in the Superior cluster were more scab tolerant than the clones in the Russet Burbank cluster. As expected, the clones in the Green Mountain cluster were the most scab susceptible. The clustering of the four check clones (Russet Burbank, Superior, Green Mountain, and Ontario) was consistent with past results (6) where Green Mountain was the most susceptible, Ontario was the most resistant, and Russet Burbank and Superior were intermediate.

This study has verified the high level of scab resistance found in Krantz, a relatively new russet-skinned potato cultivar (10). This cultivar should be considered for production by growers who have scab infested fields.

This study had also demonstrated the usefulness of cluster analysis as proposed by Goth and Haynes (6), in categorizing the scab reaction of breeding selections.

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