# Growth Rate of Young Sugar Beet Roots as a Measure of Resistance to Virus Yellows

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## Introduction

Considerable time may be required to obtain substantial results in breeding for resistance to virus yellows. The lack of criteria for an accurate determination of resistance in individual beets and the apparent absence of wide ranges of variation in resistance in the genetic material available for selection are responsible for this situation (1)[2]. Field tests are unsuitable for precise evaluation of slight differences in resistance to virus yellows among selections. Field evaluation is difficult because of yearly variation in climate, soil fertility, soil moisture and the spread of other virus diseases. A breeding program for increased resistance to virus yellows would be greatly facilitated, therefore, if a more accurate method of determining the relative resistance of beets to yellows were available.

This paper reports experiments, conducted in the greenhouse under controlled conditions, which indicate that the reduction in growth rate of the roots of inoculated plants during an early period of development may be useful in evaluating resistance to virus yellows.

## Methods, Results and Discussion

Four boxes were lined with polyethylene and filled with sterilized sand. Seed of variety US 75 was planted on 6-inch centers April 24, and watered with Hoagland's solution containing 100 ppm of nitrogen. Forty days after emergence the plants in two of the boxes were inoculated with a virulent strain of the yellows virus. Sixteen healthy plants were removed from the boxes 3, 6, 8, and 10 weeks after inoculation and the root weights determined. Roots of the infected plants were harvested 8 and 10 weeks after inoculation and their weights determined.

In a similar test, started two weeks later, 100 plants were grown in one large box in another area of the greenhouse and watered with Hoagland's solution. The plants in this test were inoculated 40 days after emergence with the virus strain used in the first test. Half of the plants were removed and the roots were weighed 8 weeks after inoculation; the remaining roots were weighed 11 weeks after inoculation. The results of these two tests are shown in Figure 1 and Table 1.

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[2] Numbers in parentheses refer to literature cited.

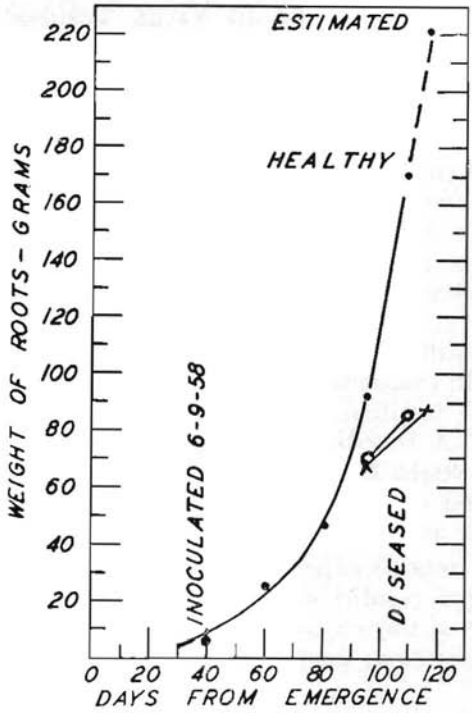


Figure 1.—Growth curve of roots of young healthy and yellows-infected sugar beet plants.

Table 1.—Growth rate of roots of healthy and yellows-inoculated sugar beet plants when inoculated 40 days after emergence.

| Growth period from emergence | | Growth rate per day | Index of resistance growth rate: Inoc./H × 100 |
|---|---|---|---|
| From | To | | |
| Day | Day | Gm | |
| Healthy Plants (H) | | | |
| 40 | 61 | 0.90 | |
| 61 | 82 | 1.05 | |
| 82 | 96 | 3.21 | |
| 96 | 110 | 5.25 | |
| Inoculated plants: Tests 1 and 2 | | | |
| 96 | 110 | 1.07 | 20 |
| 96 | 117 | 0.90 | 17 |

Leaf samples, taken from the mature leaves of each plant at the time the roots were harvested, showed the amino acid pattern for both the healthy and infected plants of that found in plants of other tests (2).

Under the conditions of these experiments, rapid growth of the roots of the healthy plants started approximately 60 to 80 days after emergence (Figure 1). During the 2-week period (beginning with the 82nd day after emergence) the mean growth rate of the roots of the healthy plants was 3.21 grams per day. The growth rate for the following 2-week period was 5.25 grams per day for the roots of the healthy plants as compared to 1.07 grams per day for the roots of the infected plants in test 1. This amounts to a reduction in the growth rate of 80% due to the disease.

In the second test, the growth rate of the infected roots for the 3-week period, (beginning with the 96th day after emergence) was 0.90 gram per day. This amounts to a reduction in the growth rate of the roots of the infected plants of 83%.

In both tests the reduction in root weight, due to the disease, was approximately 24% at the end of 8 weeks after inoculation. When the infected plants were allowed to grow 2 weeks longer the reduction in root weight of the plants in the first test was approximately 49%. By extending the growth curve of the healthy plants 7 more days, at the established rate of 5.25 grams per day, an estimated weight of 225 grams was obtained for the healthy roots. This weight as compared to 88 grams for the diseased roots shows a reduction of approximately 60% due to the disease.

The reduction in the growth rate of roots of infected plants in the early stages of growth may be an accurate criterion for the determination of resistance of selections to virus yellows. It would be necessary to make the measurements under standardized conditions nearly optimum not only for the growth of the plants but for the expression of symptoms of the disease and during the period when the virus is exerting its maximum influence on the growth of the plant. This period would be when the plant is in the acute stage of the disease. During this period both top and root growth are greatly retarded.

There is evidence that root growth may be retarded for a longer period than the top growth. The reduction in growth rate may depend upon several factors such as age of plants at the time of infection, strain of the virus used and upon the growing conditions. It is possible also that both the resistant and susceptible plants may show the same initial violet reaction to

infection but that resistant plants are able to recover from the acute stage of the disease and resume more nearly normal top and root growth in a shorter period of time than the susceptible plants.

In the tests reported, the growth rate of the roots of the infected plants was determined during the period when the plants were in the acute stage of the disease. Plants inoculated in the 4- to 6-leaf stage (40 days after emergence) and allowed a 77-day growing period before the root weights were taken resulted in a 60% reduction in root weight compared to the roots of healthy control plants. Bennett (1) reported that, in field tests, inoculation of plants in the 12- to 16-leaf stage resulted in a reduction of 34.1% in root weight, whereas inoculation 49 days later resulted in only a 12.5% reduction.

The growth rate of roots of young plants of selections made from US 75 for resistance to virus yellows and the parent was determined by essentially the same method as described. In this test the plants were inoculated with a virulent strain of the virus 60 days after emergence and root weights taken 90 and 111 days after emergence. Two selections having a growth rate superior to that of the parent and another selection which appeared to recover sooner from the acute stage of the disease were tested along with the parent in a replicated field test. The plants in the field test were inoculated in the 4- to 6-leaf stage with the same virulent strain of the yellows virus used in growth-rate test conducted in the greenhouse. The percentage increases in the growth rate of the roots and in yield per acre of roots in the field test are shown in Table 2.

**Table 2.—Growth rate of roots of young inoculated greenhouse-grown beet plants of selections in relation to their yield in a replicated field test under severe yellows conditions.**

| Selection | Growth rate per day | Increase over parent | |
|---|---|---|---|
| | | Greenhouse growth rate | Field test root yield |
| | Gm | Percent | Percent |
| US 75 (Parent) | 1.56 | | |
| 91DS-9 | 1.88 | 20.5 | 33.3 |
| 91DS-23 | 2.14 | 37.2 | 19.3 |
| 91DS-22 | 1.59 | 1.9 | 18.0 |

Two selections showing a superior growth rate of roots among the young inoculated plants yielded 33 and 19% more beets per acre than the parent in a replicated field test. The selection which appeared to recover from the acute stage of the disease sooner than the parent, yielded 18% more than the parent.

If the growth rate, of roots of healthy plants of a suitable variety, was determined under standardized conditions, the value could be used for comparison of the growth rates of roots of infected plants of all selections tested under the same conditions. The ratio (multiplied by 100) of the growth rate of the roots of infected plants, of the selection tested, to the growth rate of the roots of the healthy standard may be called the "relative resistance index" of the selection. For example, if US 75, having a growth rate of 5.25 grams per day for roots of healthy plants (Table 1), is taken as the standard and the growth rate of the roots of infected plants is taken as 1.07 grams per day, then the resistance index would be 20. A relative resistance index of 100 would indicate that the disease had no effect on the growth rate of the roots under the conditions set up. The "absolute resistance index" of a selection would be the ratio of the growth rate of roots of infected plants to the growth rate of roots of healthy plants of the same selection. Using this criterion as a measure of resistance to virus yellows, US 75 would have an "absolute resistance index" of 20 also.

Further tests are necessary to establish the optimum length of the growing period before and after inoculation of the young plants and the length of the interval during which the growth rate of the roots is determined, in order to more clearly identify those selections which may prove to be only slightly superior to the parent under severe yellows conditions in the field.

## Summary

Sugar beet plants were grown in sand and watered with Hoagland's solution containing 100 ppm of nitrogen in tests designed to measure the growth rates of roots of healthy and of yellows-infected plants during the early stages of growth. Inoculated plants grown with this concentration of nitrogen showed typical symptoms of virus yellows including necrosis. The amino acid pattern in the leaves was typical for the healthy and infected plants. In two tests, during the growing period from the 96th to the 117th day after emergence, the growth rate of the roots of the infected plants was reduced 80 and 83%, respectively, as compared with that of healthy plants. The over-all reduction in the growth rate of the roots of the infected plants for the 117 days, after emergence resulted in a 60% reduction in the weight of the roots. The tests indicate that an accurate evaluation of selections as to their relative resistance to virus yellows may be obtained in approximately 120 days after emergence. The ratio of the growth rate of roots of infected plants of a selection to the growth rate of roots of healthy plants of a selection used as

a standard is suggested as a numerical value which would serve as the "relative resistance index" of the selection in question to virus yellows. Sugar beet selections having a growth rate superior to that of the parent in young inoculated plants grown in the greenhouse, outyielded the parent in a replicated field test under severe yellows conditions.

### Literature Cited

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