THE TOMATO TEST FOR ELIMINATING SPINDLE TUBER FROM POTATO PLANTING STOCK[1]

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ARSTRACT

A lot of 792 tubers, of which about 20% were infected with the potato spindle tuber virus (PSTV), were subjected to greenhouse index tests, using tomato as a test plant. Tomato seedlings in the cotyledon stage were rubbed with the test material, either foliage or the surfaces of seed pieces cut from test tubers with a mellon-baller. Fourteen days later the test plants were inoculated with a severe strain of PSTV to detect the presence of mild strains. Tubers giving negative results were planted for propogation and those giving positive or doubtful results were planted in an observation plot. All potato plants were inspected visually and those in the observation plot were given an additional tomato test. The results indicate the validity and value of the tomato test for the elimination of PSTV from seed stocks before planting. The tuber test conducted in the winter was less efficient than the foliage test conducted in the spring. A modification of the test procedure is advocated in which two test plants are rubbed from each source, one to be challenged and one not. This increases the accuracy of the test, particularly during periods when symptoms of PSTV are poorly expressed.

RESUMEN

Un lote de 792 tubérculos, de los cuales más o menos 20% estaban infectados con el virus de papa ahusada (PSTV) fué sujeto de un ensayo de índice en invernadero, usando plantas de tomate como plantas de ensayo. Plantas germinadas de tomate con cotiledones fueron restregadas con el material de ensayo consistente ya sea de follaje, ya sea de las superficies de pedazos de papas cortadas de los tubérculos de ensayo con un cortador de melones. Catorce días más tarde las plantas de ensayo fueron inoculadas con una forma virulenta de PSTV para descubrir la presencia de formas blandas. Tubérculos que dieron resultados negativos fueron plantados para ser progados y aquellos que dieron resultados positivos o ambíguos fueron plantados en un lote de observación. Todas las plantas de papa fueron inspeccionadas visualmente y aquellas en el lote de observación recibieron un ensayo adicional con plantas de tomate. Los resultados indicaron la validez y la ventaja del ensayo por medio de plantas de tomate para la eliminación de PSTV de las papas antes de sembrar. El ensayo por medio de tubérculos conducido en invierno fue menos eficaz que el ensayo por medio del follaje hecho en primavera. Se recomienda una modificación del procedimiento de ensayo en la cual dos plantas de cada origen se restriegan y de las cuales una se examina y la otra no. Esto aumenta le exactitud del ensayo, especialmente durante los períodos cuando los síntomas de PSTV están pobremente expresados.

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An earlier publication (Fernow 1) noted the existence of a strain of potato spindle tuber virus (PSTV) which sometimes induces symptoms in tomato so mild that they easily escape detection. In our experience the mild strain predominates in potatoes exposed to infection in the field. Hence, indexing potato stocks by rubbing cut tubers or crushed leaves on tomato plants will detect only a small fraction of the PSTV infections present in field samples. Based on the discovery that infection by a mild strain protects tomatoes against subsequent infection by a severe strain, a technique involving challenge-inoculation was proposed for the index testing of potato stocks to detect the presence of PSTV. This paper presents the results of our experience in applying this procedure to 792 tubers with approximately 20% infection for the purpose of obtaining tubers free from PSTV, for propagation.

Materials and Methods

From November, 1966 through January, 1967, the first tests were made by cutting a seed piece from each tuber with a sterile melon-baller and rubbing the cut surface on the cotyledons of a Rutgers tomato plant about 10-14 days after the seed was sown in a 4-inch pot. The seedpieces were subsequently planted in the greenhouse and crushed leaves from the resulting potato plants were used from February to May in making a second tomato test. Fourteen days after the initial rubbing, the test plants were inoculated by rubbing with leaves from a plant containing a severe strain of PSTV. Plants rubbed with virus-free material react to the challenge-inoculation by the development of severe symptoms, consisting of severe down-curling of new leaves, wrinkling of upper leaves, and shortening of upper internodes. These symptoms usually show within 2 to 3 weeks from challenge-inoculation. Plants which do not show severe symptoms are judged to represent tubers containing mild strains of PSTV. These sometimes show slight epinasty, some wrinkling of the leaf surface and a reduction in the size of leaflets and general plant growth. The mild symptoms develop much slower than the severe symptoms and under unfavorable conditions may not show at all. For each group of plants tested, controls were provided consisting of non-inoculated tomato plants, and plants inoculated with severe and mild strains of PSTV. In each type of control plants some were challenge-inoculated.

When the results of both greenhouse tests were available the tubers were sorted. Those marked negative in both tests, of which there were 560, were planted in propogation plots. To facilitate roguing and minimize spread of virus, these were planted in tuber-units in rows 180 cm apart. Some of the tubers, both healthy and diseased, were discarded for reasons not connected with the tests and we have no further information about them. The tubers discarded for propogation because of unfavorable results in the foregoing tests were planted in a special observation plot as single hills spaced 46 cm in rows 90 cm apart. Planted in the observation plot were 202 tubers indicated as infected in one or both of the tomato tests, 13 tubers that had given a questionable reaction, and 17 that were suspected of containing PSTV from evidence not connected with the test, a total of 232 tubers. In July, inspections were made of the potato plants in the observation plot and in the propogation plots. In the latter, conditions for the detection of disease symptoms were excellent but were

less favorable in the observation plot. On October 10, the plants in the observation plots were dug and the tubers inspected by two persons independently and without reference to previous results. One inspector considered tubers showing slight or doubtful symptoms as positive for the presence of PSTV, the other adopted the attitude that such tubers should be recorded as negative.

Results

Of the 560 tubers selected and grown in the propogation plot, only one was found infected with PSTV. Some difficulty was experienced in the classification of the tubers grown in the observation plot because of the less favorable conditions for detection of disease symptoms and the fact that the results of the three inspections often failed to agree. It was decided to classify as "infected" those with positive records in two of the three inspections, as "probably infected" those with positive records in one inspection and as "not infected" those recorded negative in all three inspections, and they are so designated in Tables 1 and 2. Of the 30 tubers included in the observation plot in spite of negative results in both greenhouse tests, four were classified as "infected," 10 as "probably infected" and 16 as "not infected." These are included in Table 1 among the 590 tubers negative for both tests.

Table 1 shows the results of the two winter tests in comparison with the results of the three field inspections, one of vines and two of tubers. This table includes all tubers on which we have information. Table 2 contains the records of the September greenhouse test on tomatoes using, as inoculum, foliage from the 292 tubers planted in the observation plot in comparison with those from the three field inspections. Table 3 shows the results of the September greenhouse in comparison with those from each of the two winter tests.

Discussion

We recognize that the division of the tubers into the three categories, "infected," probably infected" and "not infected" is an arbitrary classification. There was considerable degree of uncertainty in the identification of disease symptoms in the observation plot because of the close planting, heavy vine growth, and the fact that each tuber was represented by only one plant and that successive plants were frequently of different varieties with unknown tuber characteristics. More than likely most of the tubers classified as "probably infected" were infected with PSTV, as undoubtedly were some of those classified as "not infected." For example, in Table 1, there is a group of nine tubers in the "not infected" column that were found to be infected in both winter tests. The plants grown from these nine tubers also gave positive results in the September tomato test. It is probable that the error in this case lies in the field inspections rather than in all three of the tomato tests. However, there are 51 tubers in the same column where the two winter tests disagree. One test is wrong. In general, the foliage test appears to have been much more efficient in identifying tubers with PSTV than the tuber test. It identified 80 of 88 tubers infected and 46 of 69 "probably infected" or about 80% in both categories. The tuber test identified 33 of the "infected" and

TABLE 1.—*Correlation of greenhouse indexing of potato tubers and foliage with field-occurrence of potato spindle tuber in plants grown from indexed tubers.*

Greenhouse index	Number tested	Field occurrence[1] Number Infected	Number Prob. infected	Number Not infected
tuber +, foliage +	55	30	16	9
tuber +, foliage —	44	3	13	28
tuber —, foliage +	103	50	30	23
tuber —, foliage —	590	5	10	575
Total	792	88	69	635

[1]Field occurrence is based on one foliage and two tuber inspections; "infected" were reported positive in at least two inspections; "probably infected" were reported positive in one inspection; "not infected" were reported negative in all three inspections.

TABLE 2.—*Correlation of field diagnosis of PSTV by foliage and tuber symptoms with greenhouse test on tomato with foliage from plants in the observation plot.*

Field diagnosis[1]	Number tested	September greenhouse test Number infected	Number Not infected
Infected	87	87	0
Probably infected	69	57	12
Not infected	76	53	23
Total	232	197	35

[1]Based on one foliage and two tuber inspections; "infected" were reported positive in at least two inspections; "probably infected" were reported positive in one inspection; "not infected" were reported negative in all three inspections.

TABLE 3.—*Correlation of results of two winter tomato indexing tests for PSTV with those of a September tomato test of plants grown from the index tubers.*

Winter indexing	Number tested	September greenhouse test Number infected	Number Not infected
tubers +	99	85	14
tubers —	133	112	21
Total	232	197	35
foliage +	158	151	7
foliage —	74	46	28
Total	232	197	35

29 of the "probably infected" groups for an average of 40%. The lower efficiency of the tuber test is difficult to explain since it has been our experience both before and since making these tests that the recovery of virus from tubers known to be infected almost always is successful. It may be that the virus titer is lower in tubers than in the foliage, especially in recently infected plants. It is more likely, however, that the relatively poor results from the tuber test are attributable to the less favorable greenhouse conditions at the time the tests were made. Singh and Bagnall (2) reported that conditions from October to December were less favorable for symptom production than at other times of year.

That some of the tubers classified as "not infected" actually contained PSTV is supported by Table 2 in which 53 of 76 tubers judged non-infected by field inspection gave a positive reaction in the tomato test conducted in September with the foliage from the field plants. Table 3 also shows the results of the September field foliage test but in comparison with each of the winter greenhouse tests. In this table it is apparent that there is good correlation with the winter greenhouse foliage test but not with the tuber test.

Although the plants in the propogation plots were not submitted to the field foliage test it is our belief that the negative results of the field inspections for 559 of the 560 tubers can be considered reliable because of the method of planting in tuber units with wide spacing and the fact that several other units of the same variety were available for comparison.

The tomato test is not suggested as a substitute for field roguing but rather as a supplement. With its aid the incidence of PSTV-infected plants in our plots grown from tested tubers has been very low during the last few years.

A recent example of our experience concerns 1-hill selections of new seedlings made in 1968. The tubers from each hill were planted in 1969 as a 10-hill unit. Some of the hills were tested by growing a plant from one tuber in the greenhouse and rubbing the foliage on tomatoes. The infected hills were then sorted out before planting. Other hills were not tested. The two lots were planted separately. Both lots have been rogued for PSTV with the following results: Tested lot: 579 units, four infected; untested lot: 507 units, 55 infected. The use of the test enables us to discard the infected tubers before planting time, thus reducing the danger of field-spread and simultaneously increasing the effectiveness of yield trials. Our experience in field roguing has demonstrated that the tomato test is not infallible. In a few cases tubers that passed the test produced plants that showed foliage symptoms. There were still others, however, that passed both the tomato test and were ngative in repeated field inspections of the vines but still produced tubers which definitely could be identified as infected with PSTV.

Our premise is that tubers for which the test gives doubtful results are infected and should be discarded. This results in the rejection of some tubers which may be virus-free. In the present study this amounted to 37 tubers from the tuber test and 32 from the foliage test or less than 0.5% of the tubers tested. This percentage is not considered a serious loss.

Since making the test here recorded, we have modified our methods

by using two tomato plants for each source tested, only one of which is challenge-inoculated. We believe the accuracy of the test is increased by this procedure. Under unfavorable conditions great reliance is placed on the appearance of the challenged plant, which will show symptoms in spite of the poor conditions while the infected but unchallenged plants appear very similar to the healthy, unchallenged control plants. If conditions are found to be favorable, however, most of the infected, unchallenged plants show very clear symptoms of the mild type and the challenge technique is less important. Its use may be helpful in interpreting doubtful results.

Literature Cited

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