Enanismo Amarillo Disease of Solanum andigena Potatoes is Caused by Potato Leaf Roll Virus

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Part of thesis submitted by the senior author in partial fulfilment of requirements for the MS degree, Universidad Nacional Agraria, Lima, Peru.

We thank C. E. Fribourg (Universidad Nacional Agraria, Lima) for helpful discussion and supplies of antisera, and I. Block de Balbo and J. Rocha for technical assistance.

Accepted for publication 6 June 1977.

ABSTRACT

RODRIGUEZ, A. and R. A. C. JONES. 1978. Enanismo amarillo disease of Solanum andigena potatoes is caused by potato leaf roll virus. Phytopathology 68:39-43.

"Enanismo amarillo" disease which is perpetuated by infected seed tubers was found to be widely distributed in fields of *Solanum andigena* 'Renacimiento' potato in the potato-growing areas of central Peru. Symptoms in diseased plants of seven different *S. andigena* cultivars were: marginal and interveinal chlorosis of leaflets, a marked upright habit of growth, and stunting. Although potato leaf roll virus (PLRV) was detected in diseased plants of all seven cultivars by aphid transmission to *Physalis floridana* seedlings and was the only virus consistently isolated from them, the rolling of lower leaves which is typical of secondary infection with this virus in *S. tuberosum* and *S. tuberosum* × *S. andigena* cultivars was an additional symptom in affected plants of only one of them. Isolates of PLRV from plants of two different *S. andigena* cultivars with the disease induced secondary rolling of lower leaves in the *S. tuberosum* cultivar Arran Pilot and an isolate from a plant of the *S. tuberosum* × *S. andigena* cultivar Ticahuasi showing pronounced rolling of lower leaves induced "enanismo amarillo" disease as secondary symptoms in Renacimiento. The disease, therefore, constitutes the typical response of *S. andigena* to secondary infection with PLRV.

Additional key words: potato virus disease, symptomatology.

RESUMEN

RODRIGUEZ, A. and R. A. C. JONES. 1977. Enanismo amarillo disease of Solanum andigena potatoes is caused by potato leaf roll virus. Phytopathology 67.

La enfermedad conocida como "enanismo amarillo", la cual es perpetuada por tubérculos semilla infectados, se encontró ampliamente distribuída encampos de papa *Solanum andigena* del cultivar Renacimiento en áreas productoras de papa de la parte central del Perú. Los síntomas en plantas enfermas de siete cultivares diferentes de *S. andigena* fueron clorosis marginal e intervenal de foliolos, un marcado hábito de crecimiento erecto y enanismo. Aunque fue detectado PLRV en plantas enfermas de todos los siete cultivares usando transmisión por áfidos a plántulas de *Physalis floridana* y siendo el único virus aislado consistentemente de ellas, el enrollamiento de las hojas inferiores típico de infección secundaria con este virus en cultivares de *S. tuberosum* y *S. tuberosum*×*S. andigena* fue un síntoma adicional en plantas afectadas de solo uno de ellos. Aislamientos de PLRV procedentes de plantas con la enfermedad de dos cultivares diferentes de *S. andigena* indujeron enrollamiento secundario de hojas inferiores en el cultivar de *S. tuberosum* Arran Pilot y un aislamiento procedente de una planta del cultivar Ticahuasi *(S. tuberosum* × *S. andigena)* que mostraba enrollamiento marcado de hojas inferiores indujo "enanismo amarillo" como síntomas secundarios en Renacimiento. La enfermedad por consiguiente, constituye la respuesta típica de *S. andigena* a la infección secundaria con PLRV.

Palabras claves adicionales: enfermedad de virus de papa, sintomatología.

Although McKee (6) showed that infection with potato leaf roll virus (PLRV) may be common in potatoes in Andean countries, the rolling of lower leaves symptom which is typical of secondary infection with this virus in plants of the Irish potato, *Solanum tuberosum* L., (3) has not been recorded in plants of *Solanum andigena* Juz. et Buk. potatoes growing in the region. By contrast, this symptom is often present in plantings of *S. tuberosum* × *S. andigena* cultivars.

When fields of the *S. andigena* cultivar Renacimiento were examined in 1974 in the Peruvian coastal valley of Cañete, no typical secondary PLRV symptoms were seen. However, a proportion of plants in several fields showed symptoms consisting of leaflet chlorosis, a marked upright habit of growth and stunting. Although not previously recorded in Peru, these symptoms are widespread in potatoes in Colombia where they have been known for over 25 yr as "enanismo amarillo", a serious disease of unknown cause which is transmitted through seed potato tubers (1, 4, 5, 7). Preliminary tests on plants of Renancimiento with "enanismo amarillo" revealed infection with PLRV (10, 11). This paper demonstrates that this disease is the typical response of *S. andigena* to secondary infection with this virus.

0032-949X/78/000006 $03.00/0

MATERIALS AND METHODS

Samples. — These were collected as cut shoots. Those of Colombian cultivars were from plants growing in the field in Peru in 1975 from tubers introduced from Colombia in 1974. Samples of Peruvian cultivars were from fields in several different localities in the Andean highlands and coastal irrigated desert valleys of central Peru.

Experimental plants. — Seedlings of indicator plants were transplanted to a sterlized soil, sand, peat mixture, and the plants kept in an aphid-free screenhouse at 16-25 C. Healthy plants of Renacimiento and of the Scottish cultivar Arran Pilot were supplied by the International Potato Center seed potato program. Potatoes in the field were protected from insects by application of Aldicarb [2-Methyl-2-(methylthio) propionaldehyde, *O*-(methyl carbomyl) oxime] granules at planting time and after emergence by spraying with methyl parathion (0, 0-Dimethyl *O*-p-nitrophenyl thiophosphate) every 2 wk.

Aphid transmission tests. — Populations of the aphid *Myzus persicae* Sulz. were reared on plants of chinese cabbage, *Brassica pekinensis* Lour (Rupr.), and used for backtesting samples for PLRV to seedlings of *Physalis floridana* Rydb. (8). About 60 aphids were transferred to each sample, allowed to feed for 3 days, transferred to 10 *P. floridana* seedlings (five aphids per seedling), allowed to feed for a further 2-3 days, and then killed by spraying with Tamaron (Amido-*O*-methyl-S-methyl phosphate). As a control, 50 aphids were transferred directly from chinese cabbage to another 10 *P. floridana* seedlings. Both samples and *P. floridana* seedlings were retained in isolation in screened cages. In summer, the seedlings were placed in a screenhouse after they were sprayed, but in winter a polyethylene-lined screenhouse cubicle heated to about 25 C was used to obtain distinct PLRV symptom expression.

Mechanical inoculation tests. — To test for mechanically transmitted viruses, a cotton-tipped swab was used to rub leaf sap onto leaves dusted with 22-μm (600-mesh)

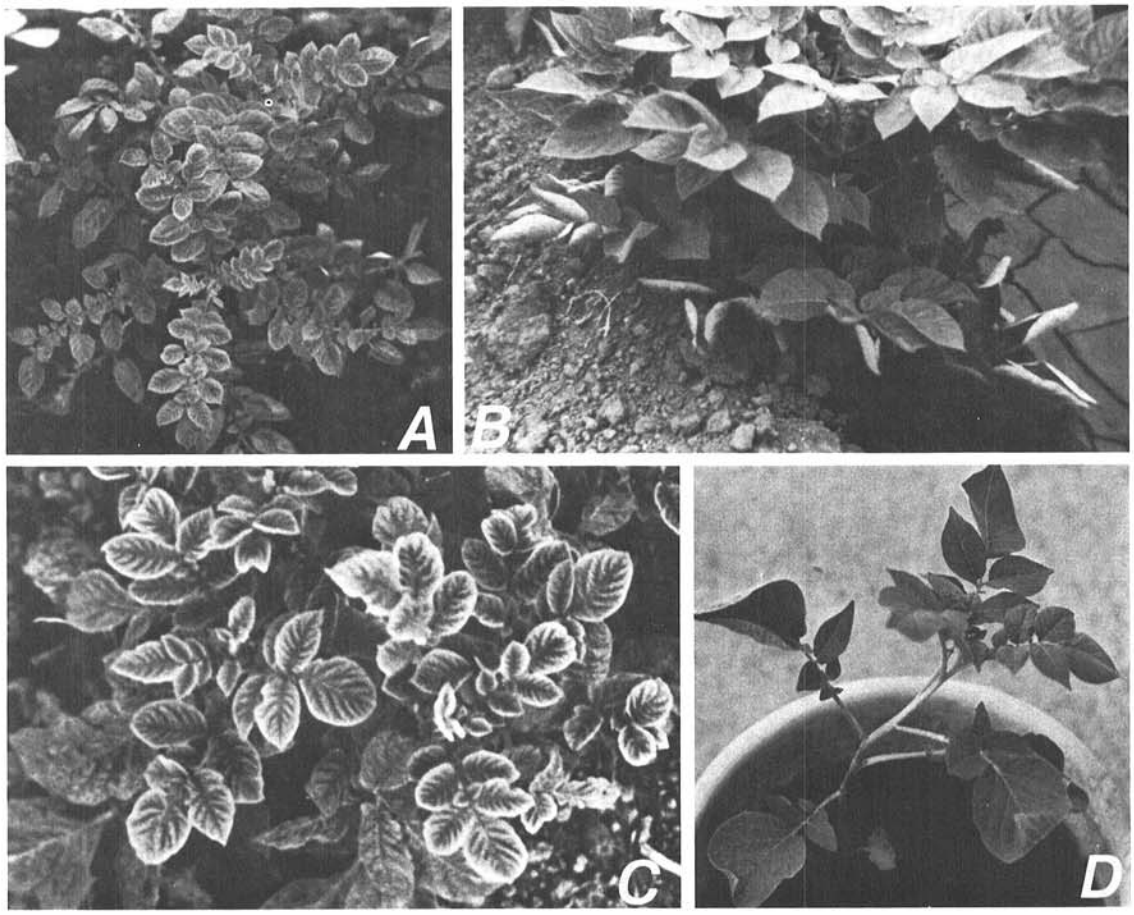

Fig. 1. Symptomatology of potato leaf roll virus (PLRV) in Andean (A to C) and European (D) potato cultivars or clones. **A)** Plant of *Solanum andigena* 'Renacimiento' severely affected by "enanismo amarillo" disease. **B)** Typical secondary leaf roll symptoms in (*S. tuberosum* × *S. andigena* 'Ticahuasi'. **C)** "Enanismo amarillo" disease in plant of an *S. andigena* clone of the Central Colombian potato germplasm collection. **D)** Typical secondary leaf roll symptoms induced in *S. tuberosum* 'Arran Pilot' by a PLRV isolate from a plant of *S. andigena* 'Parda Pastusa' with "enanismo amarillo" disease.

Carborundum. Two plants of each of the following indicator species were inoculated for each sample tested: *Chenopodium amaranticolor* Coste & Reyn., *C. quinoa* Willd., *Gomphrena globosa* L., *Nicotiana bigelovii* Wats., *N. glutinosa* L., and *N. tabacum* L. 'Samsun'. Detached leaves of clone A6 (*Solanum demissum* Lindl. × *S. tuberosum* 'Aquila') also were inoculated.

Serological tests. — A modification of the micro-precipitin method of Ball (2) was employed. Drops of antiserum and antigen were placed on plastic petri plates, mixed by putting the plates on a mechanical shaker for 10-15 min, and then incubated in a most chamber for 1 hr. Samples of leaf sap were tested concurrently against antiserum to potato virus S (PVS), potato virus X, and potato virus Y. Andean potato latent virus antiserum was used sometimes also.

RESULTS

"Enanismo amarillo" disease symptoms. — Symptoms in the cultivar Renacimiento consisted of a marginal and interveinal chlorosis of leaflets especially of upper leaves, a marked upright habit of growth and stunting which was often severe (Fig. 1-A). When diseased plants of six Colombian S. *andigena* cultivars growing in the field were examined, symptoms like those in Renacimiento were present in the cultivars Argentina, Beleña, Chava Blanca, and Tocana Rosada. In cultivar Parda Pastusa, however, purpling of the undersides of some leaves was an additional symptom, and diseased Tuquerreña plants also had both this purling and distinct rolling of lower leaves. Plants of Renacimiento reacted like Tuquerreña when growing in poorly fertilized soil in pots or in the field under unusually warm conditions but under normal growing conditions distinct rolling of lower leaves was relatively rare in diseased plants of this cultivar.

Incidence. — In 1975, a survey was made of the incidence of "enanismo amarillo" disease in fields of the cultivar Renacimiento in the three principal seed potato growing regions of the highlands of central Peru and the two most important coastal valleys for potato production (Table 1). Fields of the *S. tuberosum* × *S. andigena* cultivar Ticahuasi also were examined and the incidence of typical secondary leaf roll symptoms recorded. This cultivar is very susceptible to PLRV and plants with secondary infection show distinct rolling of lower leaves (Fig. 1-B).

"Enanismo amarillo" disease was present in Renacimiento crops in each of the regions. Incidences of the disease were highest in the Huanuco valley and Chaglla and on the coast, reaching a maximum of 46% in one field. Parallel results were obtained for PLRV symptoms in crops of cultivar Ticahuasi but percentages of affected plants tended to be somewhat greater. Detailed results of this survey are described by Rodriguez (9).

In 1975, "enanismo amarillo"-diseased plants were present in some of the *S. andigena* clones of both the International Potato Center germplasm collection in Peru and the Central Colombian collection in Colombia (Fig. 1-C).

Association with potato leaf roll virus. — Potato leaf roll virus was detected in samples from "enanismo amarillo" diseased Renacimiento plants in each of the regions listed in Table 1, by aphid transmission to *P. floridana.* It was also found in at least two samples from diseased plants of each of the cultivars Argentina, Beleña, Chava Blanca, Parda Pastusa, Tocana Rosada, and Tuquerreña. Although potato virus S was commonly detected in diseased Renacimiento plants, tests using serology and inoculation to a range of indicator hosts

TABLE 1. Incidence of "enanismo amarillo" and typical secondary leaf roll in crops of the potato cultivars Renacimiento and Ticahuasi, respectively, in different localities in Peru in 1975

Locality[a]	Cultivar[b]	Fields with infected plants/ total fields (no.)	Fields with incidence over 2.5% (no.)	Range of incidence
Huanuco valley and Chaglla (1,900-3,000 m)	R [17][c]	26/28	9	Trace-46%
	T [9]	6/ 6	2	Trace-65%
Huasa-huasi (2,900-3,600 m)	R [9]	7/16	2	Trace- 3%
	T [7]	15/20	3	Trace-47%
Mantaro valley and Comas (3,200-3,800 m)	R [23]	9/31	2	Trace-15%
	T [27]	2/ 5	1	Trace-40%
Canete valley and Barranca (10-250 m)	R[d] [87]	17/21	2	Trace-15%
	T [156]	29/37	15	Trace-39%

[a] Figures in parentheses show range of altitude of fields examined (in meters above sea level).
[b] Cultivar name abbreviations: R=Renacimiento, T=Ticahuasi.
[c] Figures in square brackets show estimated total area of fields inspected (in hectares).
[d] Includes data from some fields inspected in 1974.

failed to reveal the presence of any virus in addition to PLRV that could be isolated consistently from samples of plants of different *S. andigena* cultivars with these symptoms.

Effect of Andean potato leaf roll virus isolates. — Differences in symptomatology between *S. andigena and S. tuberosum* might reflect the presence of a PLRV strain in the Andean region inducing somewhat different symptoms from normal strains. To test this, aphids taken from chinese cabbage were fed for 3 days on plants of Renacimiento with "enanismo amarillo" disease, transferred to each of nine young healthy plants of the highly PLRV susceptible *S. tuberosum* cultivar Arran Pilot (50-60 aphids per plant) and allowed to feed on them for 3 days. As a control, aphids taken directly from chinese cabbage were transferred to nine other Arran Pilot plants. Upper leaves of some of the plants inoculated using aphids taken from Renacimiento plants later developed a rolling of the basal halves of leaflets and a purpling of leaflet undersides, which are typical primary PLRV symptoms in *S. tuberosum*. Tubers were harvested from all the plants, sprouted, and some were planted in pots in a screenhouse and others in the field. Plants derived from tubers of plants originally inoculated using aphids taken from Renacimiento plants developed mild stunting and the distinct rolling of lower leaves typical of secondary PLRV symptoms in *S. tuberosum*. Those growing in pots also developed strong purpling of the undersides of rolled leaves as an additional symptom. Similar tests in which plants of Parda Pastusa with "enanismo amarillo" and Ticahuasi with rolled lower leaves were used as PLRV sources gave the same result (Fig. 1-D). No symptoms developed in control plants.

In a further test, healthy Renacimiento plants were inoculated with PLRV from a Ticahuasi source plant with rolled lower leaves. No primary symptoms were induced, but marginal and interveinal chlorosis of leaflets of upper leaves, a marked upright habit of growth, and stunting (i.e., "enanismo amarillo" disease) developed in plants grown from tubers harvested from the PLRV-inoculated plants and planted in pots in the screenhouse. Control Renacimiento plants grown from tubers from plants fed on by aphids transferred directly from chinese cabbage showed no symptoms.

Samples from these experiments were tested by aphid transmission to *P. floridana* to confirm the presence of PLRV. The virus was detected in plants of Arran Pilot with rolled lower leaves and of Renacimiento with "enanismo amarillo", but not in control plants of either cultivar. The same samples also were tested by inoculation to a range of indicator hosts but no virus transmissible mechanically was detected in any.

Secondary symptoms of potato leaf roll virus in Solanum tuberosum × S. andigena cultivars.—The typical rolling of lower leaves which develops in *S. tuberosum* was associated with secondary infection with PLRV in all of the five *S. tuberosum* × *S. andigena* cultivars (four Peruvian and one Colombian) examined growing in the field (Fig. 1-B). Presence of PLRV in at least three samples from diseased plants of each was confirmed by aphid transmission to *P. floridana*. Other predominant symptoms were purpling of the undersides of rolled leaves in the Colombian cultivar Ica Purace, this same purpling plus some degree of stunting in Ticahuasi and some leaflet chlorosis in Merpata. However, the reactions of Antarqui and Mariva more resembled that of *S. andigena*. A marginal and interveinal chlorosis of leaflets, an upright growth habit, and stunting developed in diseased plants of these in addition to the rolling of lower leaves.

Virulence of Andean potato leaf roll virus isolates. — *Physalis floridana* reacts to infection with PLRV by producing a marginal and interveinal chlorosis of leaves and stunting. Wright et al. (12) divided PLRV strains into four types based on the degree of stunting induced in this host: very mild, mild, moderate, and severe. All four types occurred in our tests on Andean cultivars but most were either moderate or severe. There was a tendency to isolate the severe strain more often from *S. andigena* than from *S. tuberosum* × *S. andigena* cultivars.

DISCUSSION

In Colombia, Nieto (7) isolated PLRV from *S. andigena* potato plants with "enanismo amarillo" disease, but did not realize that it might be the causal agent. We found PLRV widespread in crops of an *S. tuberosum* × *S. andigena* cultivar in regions of Peru where "enanismo amarillo" was common in Renacimiento crops. The rolling of lower leaves typical of secondary PLRV infection in *S. tuberosum* and *S. tuberosum* × *S. andigena* cultivars was always associated with the disease in plants of one of the Colombian *S. andigena* cultivars examined (Tuquerreña) and developed in diseased plants of Renacimiento growing under conditions of stress. Potato leaf roll virus was the only virus consistently isolated from plants of different cultivars with the disease. Moreover, isolates from affected plants induced typical primary and secondary symptoms of this virus when aphid-inoculated to an *S. tuberosum* cultivar, and an isolate from a plant of an *S. tuberosum* × *S. andigena* cultivar with rolling of lower leaves induced "enanismo amarillo" as a secondary reaction in Renacimiento. The disease thus constitutes the typical response of *S. andigena* to secondary infection with PLRV. Studies on the response of *S. andigena* to primary infection with this virus were not made, but Renacimiento plants aphid-inoculated with it were infected without producing symptoms.

Previous failure to realize that "enanismo amarillo" disease is caused by PLRV was because affected plants of most *S. andigena* cultivars do not develop the symptom from which the virus gets it name, the typical rolling of lower leaves. Lack of knowledge of the symptomatology of PLRV in *S. andigena* which is the most widely grown type of potato in the Andean region, has meant that the importance of the virus to potato cultivation in the Andes has been greatly underestimated.

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