Effects of Seedborne Potato Leafroll Virus on Russet Norkotah Potato

P. B. Hamm, Extension Plant Pathologist, Department of Botany and Plant Pathology, and **D. C. Hane**, Research Agronomist, Department of Crop and Soil Science; Oregon State University, Hermiston Agricultural Research and Extension Center, P.O. Box 105, Hermiston 97838

ABSTRACT

Hamm, P. B., and Hane, D. C. 1999. Effects of seedborne potato leafroll virus on Russet Norkotah potato. *Plant Dis.* 83:1122-1124.

Tuber yield and quality of cv. Russet Norkotah potato plants grown from seed infected with potato leaf roll virus (PLRV) were compared with tuber yield and quality of adjacent plants grown from virus-free seed. Plants from PLRV-infected seed produced at least 60% less total yield and 88% less marketable yield (tubers >85 g) than plants grown from healthy seed. PLRV-infected seed also produced plants with fewer and smaller tubers than plants grown from healthy seed. No compensatory yield was measured in plants grown from PLRV-free seed growing adjacent to plants from PLRV-infected seed.

Potato leafroll virus (PLRV), a disease of significance in potato (7), is spread primarily by the green peach aphid *Myzus persicae* (10). PLRV-infected seed reduced yield of potato cvs. Chippewa, Corrie, Green Mountain, Irish Cobbler, Katahdin, Kennebec, Netted Gem (Russet Burbank), and Triumph (2-4,6,8,9). Killick (3) reported a reduction in number of stems per plant, number and weight of small (culls; <3.81 cm in diameter) and marketable tubers, and average tuber weight for cv. Corrie. In contrast, Murphy et al. (8) reported increased specific gravity and lighter chip color from PLRV-infected plants of cvs. Katahdin and Kennebec. Additionally, a compensatory yield increase has been reported for healthy plants bordering plants grown from PLRV-infected tubers (2,4).

Russet Norkotah, a recently released potato cultivar, has become the most popular fresh-market potato cultivar in western North America because of production of uniformly shaped tubers with attractive russet skin. PLRV has been reported on cv. Russet Norkotah (14) but the effect of PLRV on yield has not been measured. The impact of PLRV on cv. Russet Norkotah was examined by comparing (i) tuber yield and quality between plants from PLRV-free seed and plants from PLRV-infected seed, and (ii) yield of PLRV-free plants growing adjacent to

plants from PLRV-infected seed and adjacent to PLRV-free plants.

MATERIALS AND METHODS

Field experiments were conducted in 1994 and 1995 under center-pivot irrigation systems in the Columbia Basin of Oregon, a low-elevation (<450 m), desert environment with a growing season of 180 or more days.

On 1 June 1994, a commercial field of cv. Russet Norkotah potatoes was scouted for the likely occurrence of plants from PLRV-infected seed. PLRV-infected plants were carefully selected only when all of the following criteria were met: (i) plants possessed typical PLRV symptoms (slightly off-color, coarse-feeling rolled leaves); (ii) symptom expression occurred throughout the plant (current-season PLRV infection typically expresses symptoms primarily in the upper canopy); and (iii) the PLRV-infected plant was adjacent to plants in the row that appeared healthy. Aphid vector populations are always low during the spring, and PLRV symptoms were present on the first formed leaves of selected plants; therefore, plants selected with the above criteria were considered PLRV-infected from seed. Seed had been planted 23 March and emerged about 1 May. Intra-row spacing of plants was approximately 25 cm. Inter-row spacing was 86 cm. Plants were approximately 30 cm tall at the time of selection. Leaf samples taken from symptomatic plants and two consecutive, adjacent symptomless plants were tested for PLRV and potato virus Y (PVY) using enzyme-linked immunosorbent assays (ELISA). The study was carried out on 25 replications, confirmed by ELISA, of PLRV-infected plants growing adjacent to two PLRV-free plants, as described above. All plants selected were initially free of PVY, which reduces yield in this cultivar (1,11). The experimental

design was a randomized complete block. Vines were killed by applying sulfuric acid (102 liters/ha) on 7 July. The PLRV-infected plant, the adjacent plant grown from PLRV-free seed, and the third plant in sequence (i.e., the non-adjacent healthy plant also grown from PLRV-free seed) were individually hand harvested and bagged on 21 July. Total tuber weight, tuber number, and tuber specific gravity (air/water weight) were measured for each plant.

Similar comparisons were conducted in 1995. Seed for 1995 originated from the 1994 experiment. Tubers of plants originating from PLRV-free seed grown in 1994 were pre-tested by growing single buds of individual tubers in the greenhouse and assaying for PLRV and PVY using ELISA. Healthy and PLRV-infected seed was selected for use in 1995. This provided both a uniform seed source and restricted the origin of PLRV infection in seed to the 1994 growing season.

On 17 April 1995, field plots were established by planting five rows of certified cv. Russet Norkotah seed. Intra-row plant spacing was 24 cm and inter-row spacing was 86 cm. Certified (disease-free) seed was replaced with either PLRV-infected or PLRV-free seed from the 1994 experiment, as described above. A total of 25 replications were used, each consisting of a PLRV-infected plant and two adjacent PLRV-free plants (adjacent healthy and non-adjacent healthy plants). Each replication was separated in the row by two plants and between rows by one or several plants grown from certified seed. Plots were managed using cultural practices recommended for this area.

Shortly after 100% emergence (24 May), all plants were tested for PLRV and PVY by ELISA to confirm if they were virus infected. As in 1994, only replications with the desired PLRV infections and free of PVY were used. Plants were killed by a severe hailstorm on 9 July, and harvested on 9 August. Data for each plant in each replication was gathered as previously described from 1994. In addition, yield of marketable tubers was determined as total weight of tubers weighing >85 g.

Differences in tuber weight, number, and specific gravity between plants from PLRV-infected seed and those from the adjacent healthy plant and the non-adjacent healthy plants were tested using analysis of variance and a 5% level of significance (LSD) for separation of means (13). Be-

Corresponding author: Philip B. Hamm
E-mail: Philip.B.Hamm@orst.edu

Oregon State University Agricultural Experiment
Station Technical Paper 11482.

Accepted for publication 3 September 1999.

Publication no. D-1999-1018-03R
© 1999 The American Phytopathological Society

cause treatments are in a spatial sequence (PLRV-infected plant, adjacent healthy plant, and non-adjacent healthy plant) rather than randomized, the *F* tests for treatments using the randomized block model are only valid if the data satisfy the standard assumptions for repeated measures in space (5). The data were consistent with that assumption according to Mauchly's test.

RESULTS AND DISCUSSION

Total yield of tubers from plants grown from PLRV-infected seed (range 249 to 1,519 and 15 to 569 g for 1994 and 1995, respectively) was 61 and 68% less than the adjacent plants grown from PLRV-free seed (range 1,020 to 2,699 and 440 to 1,513 g for 1994 and 1995, respectively; Table 1). A similar difference in yield, 65%, was observed between the PLRV-infected plants and the non-adjacent healthy plants (range 862 to 3,674 and 340 to 1,331 g for 1994 and 1995, respectively) during both years. This yield reduction is comparable to that observed by Harper et al. (2) for yield loss in cv. Russet Burbank potatoes with mild PLRV symptoms. Yield reductions due to PLRV of 37 to >90% are reported for other cultivars (3,4,6,8,9), suggesting that cultivars are differentially affected by seedborne PLRV. Yield of tubers weighing >85 g was reduced by 89 and 88% in plants from PLRV-infected seed (range 0 to 387 g) compared to the adjacent healthy plants (range 92 to 1,101 g) and the non-adjacent healthy plants (range 93 to 1,163 g), respectively (Table 1). This yield reduction is reflected in the reduced average tuber size for plants grown from PLRV-infected seed (40 to 168 and 15 to 76 g for 1994 and 1995, respectively) compared to the adjacent healthy plants (range 118 to 290 and 43 to 111 g for 1994 and 1995, respectively) and the non-adjacent healthy plants (range 45 to 413 and 44 to 144 g for 1994 and 1995, respectively). Tuber weight is important in marketing of this variety; therefore, reduc-

tion in marketable yield may be a more reliable assessment of the economic effect of seedborne PLRV than reduction in total yield. The marketable yield reductions reported in these experiments are substantially greater than the 65% (for tubers >3.81 cm in diameter) and 64% in weight of marketable tubers reported from plants grown from PLRV-infected seed of cvs. Corrie and Netted Gem (Russet Burbank), respectively (3,9). Cv. Russet Norkotah may respond differently to PLRV-infection than cvs. Corrie or Netted Gem, or perhaps a portion of the response measured here is associated with a difference in the definition of marketable tubers. Tubers of cv. Russet Norkotah must meet minimum weight (124 g) or diameter (2.54 cm) criteria, so direct comparison with the criteria used by Killick (3) is impossible, as is the comparison with Nelson and Torfason (9), because they did not identify the criteria used to classify marketable yield. Yield differences between years were likely due to a shortened season in 1995 but may have also been affected by differences in yield reported to occur with cv. Russet Norkotah between years (12).

Yield compensation (yield increases by healthy plants adjacent to PLRV-infected plants) has been reported with PLRV (2,4). However, in these trials, compensating yield was not observed, although this study did not measure the yield of a healthy plant growing between two plants from PLRV-infected seed.

Plants grown from PLRV-infected seed produced fewer tubers (range 1 to 13 and 3 to 12 tubers/plant for 1994 and 1995, respectively) than the adjacent healthy plants (range 3 to 15 and 7 to 26 tubers/plant for 1994 and 1995, respectively) and the non-adjacent healthy plants (range 5 to 21 and 5 to 20 tubers/plant for 1994 and 1995, respectively; Table 1). This agrees with information reported by Killick (2), who observed a reduction in numbers of tubers from PLRV-infected plants.

Specific gravity was reduced as a result of PLRV-infected seed in 1994 but not in 1995 (Table 1). The low specific gravity of PLRV-free tubers in 1995 may be associated with the shortened growing season when vines were killed before the maximum specific gravity was achieved. Murphy et al. (8) reported that specific gravity increased with PLRV-infected seed in potato cvs. Katahdin and Kennebec, differing from the results reported here for cv. Russet Norkotah. However, since cv. Russet Norkotah is sold only for fresh market consumption, the impact of PLRV-infected seed on specific gravity is not an important consideration.

Reducing levels of PLRV in cv. Russet Norkotah seed is important. Substantial yield reduction occurs and plants originating from PLRV-infected seed can become virus reservoirs with somewhat enhanced attraction to green peach aphids, increasing the risk of current-season virus spread to healthy plants. Current-season spread in commercial fields can cause substantial reduction in quality in some cultivars (7). Planting PLRV-free seed and controlling green peach aphids reduce the risk associated with this virus, both in seed and commercial fields.

Cv. Russet Norkotah appears to be severely impacted by potato viruses. Previous reports document the significant yield reduction that occurs due to planting PVY-infected seed (1), particularly in the Columbia Basin (11). The work reported here also demonstrates the significant yield reduction when planting PLRV-infected seed.

ACKNOWLEDGMENTS

We thank J. Jaeger for technical assistance, P. Thomas for supplying antiserum, The Oregon Potato Commission for monetary support, and J. McMorran and G. Clough for reviewing the manuscript.

LITERATURE CITED

1. Hane, D. C., and Hamm, P. B. 1999. Effects of seedborne potato virus Y infection in two potato cultivars expressing mild disease

Table 1. The effect of potato leafroll virus (PLRV)-infected seed on tuber yield, number, size, and specific gravity of cv. Russet Norkotah potatoes

Year and treatment ^t	Yield (g/plant) ^s				Number ^w	Weight (g) ^x	Specific gravity
	Total ^u	% change	Marketable ^v	% change			
1994							
PLRV-infected	689 a	...	nr ^y	...	6.8 a	101 a	1.068 a
Adjacent healthy	1,751 b	-60.7 ^z	nr	nr	9.5 b	189 b	1.074 b
Non-adjacent healthy	1,964 b	-64.9	nr	nr	11.5 b	171 b	1.074 b
1995							
PLRV-infected	310 a	...	60 a	...	7.4 a	42 a	1.070 a
Adjacent healthy	968 b	-68.0	549 b	-89.1 ^z	13.2 b	73 b	1.070 a
Non-adjacent healthy	884 b	-64.9	518 b	-88.4	11.9 b	74 b	1.069 a

^s Within experimental year, numbers in columns followed by the same letter are not significantly different at *P* = 0.05.

^t Plants tested by enzyme-linked immunosorbent assay (ELISA) to confirm status as either PLRV-infected or healthy.

^u Average weight of all tubers/plant, regardless of size.

^v Average weight of tubers/plant that were of marketable size, >85 g.

^w Average number of tubers/plant.

^x Average tuber weight/plant.

^y Not recorded in 1994.

^z Figured as [(adjacent healthy plant - PLRV-infected plant)/adjacent healthy plant] × 100 for the adjacent healthy plant, and [(non-adjacent healthy plant - PLRV-infected plant)/non-adjacent healthy plant] × 100 for the non-adjacent healthy plant.

- symptoms. *Plant Dis.* 83:43-45.
2. Harper, F. R., Nelson, G. A., and Pittman, U. J. 1975. Relationship between leafroll symptoms and yield of Netted Gem potato. *Phytopathology* 65:1244-1249.
3. Killick, R. J. 1979. The effect of infection with potato leaf roll virus (PLRV) on yield and some of its components in a variety of potato (*Solanum tuberosum*). *Ann. Appl. Biol.* 91:67-74.
4. Kirkpatrick, H. C., and Blodgett, F. M. 1943. Yield losses caused by leafroll of potatoes. *Am. Potato J.* 20:53-56.
5. Kuel, R. O. 1994. *Statistical Principles of Research Design and Analysis*. Chapter 15. Duxbury Press, Belmont, CA.
6. LeClerc, E. L., Lombard, P. M., Eddins, A. H., Cook, H. T., and Campbell, J. C. 1944. Effect of different amounts of spindle tuber and leaf roll on yield of Irish potatoes. *Am. Potato J.* 21:60-71.
7. Manzer, F. E., Merriam, D. C., Storch, R. H., and Simpsom, G. W. 1982. Effect of time of inoculation with potato leafroll virus on development of net necrosis and stem-end browning in potato tubers. *Am. Potato J.* 59:337-349.
8. Murphy, H. J., Goven, M. J., and Merriam, D. C. 1966. Effect of three viruses on yield, specific gravity, and chip color of potatoes in Maine. *Am. Potato J.* 43:393-396.
9. Nelson, G. A., and Torfason, W. E. 1974. Associative effects of leaf roll and ring rot on disease expression and yield of potatoes. *Am. Potato J.* 51:12-15.
10. Peters, D. 1987. Spread of viruses in potato crops. Pages 126-143 in: *Viruses of Potatoes and Seed-Potato Production*. J. A. de Bokx and J. P. H. van der Want, eds. Pudoc, Wageningen, Netherlands.
11. Rykbost, K. A., Hane, D. C., Hamm, P. B., Voss, R., and Kirby, D. 1999. Effects of seedborne Potato Virus Y on Russet Norkotah performance. *Am. J. Potato Res.* 75:91-96.
12. Rykbost, K. A., and Maxwell, J. 1993. Effects of plant population on the performance of seven varieties in the Klamath Basin of Oregon. *Am. Potato J.* 70:463-474.
13. SAS Institute Inc. 1988. *SAS/STAT User's Guide*. Release 6.03 Edition. SAS Institute Inc., Cary, NC.
14. Whitworth, J. L., Sampson, R. G., Allen, T. C., and Mosley, A. R. 1993. Detection of potato leafroll virus by visual inspection, direct tissue blotting and ELISA techniques. *Am. Potato J.* 70: 497-503.