POTATO PRODUCTION WILL BE POSSIBLE WITHOUT APHICIDES OR FUNGICIDES

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ABSTRACT

The USDA-ARS potato germplasm enhancement program at Prosser, Wa., has identified lines that are sufficiently resistant to virus and early dying diseases that they can be produced with very little use of pesticides. Results of tests the past four years offer convincing evidence that multi-resistant potato genotypes are available that produce a full crop of good grade, high quality tubers under severe disease exposure in the Northwest without use of aphicides such as aldicarb (Temik) or methamidophos (Monitor) to control virus diseases. These multi-resistant lines also produce well without fumigation or fungicides, even on soils where Verticillium wilt is a serious problem and where scab, Sclerotinia wilt, early blight, and powdery mildew might normally cause serious losses. The productivity and quality of these lines are about the same whether grown with or without these pesticides. They usually outperform Russet Burbank, the principal cultivar in the Northwest, especially under disease exposure. Twenty of these lines are being increased in commercial seed areas so they can be evaluated in Tri-State and regional trials and in growers' fields to determine their potential for release as commercial cultivars or germplasm for other breeders. Results of resistance characterization studies in 1990 showed that these multi-resistant lines are usually inhabited by fewer aphid virus vectors, contain less potato leafroll and Y viruses, and less Verticillium propagules than commercial cultivars commonly produced in the West. This results in plants that are less susceptible to environmental stresses and stay healthy much longer in the fall, even under severe disease exposures. This, in turn, results in large yield and quality advantages that will increase profits for all aspects of the potato industry and reduce grower risks and environmental pollution by pesticides.

INTRODUCTION

As costs of potato production continue to spiral upward and environmental concerns associated with agriculture continue to escalate, there is an increasing need for improved cultivars that can be produced more economically, with less risks involved and less use of pesticides. The USDA-ARS potato breeding program conducted at the Prosser Irrigated Agriculture Research and Extension Center concentrates on development of disease, pest, and stress resistant potatoes that will minimize costs and risks in production and reduce the need for pesticides that might pollute the environment or concern consumers (4, 5, 6, 8, 9, 10, 13, 13).

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We have accumulated a worldwide collection of breeding lines and cultivars with worthwhile resistance to virus, early dying, nematode, and tuber blemish diseases that trouble the potato industry in the Northwest. These have been intensively evaluated for all important disease and stress related factors and for a long list of horticultural characteristics needed by the potato industry (1, 2, 3, 4, 6). The most promising resistant lines with adaptability to production in the Columbia Basin have been intercrossed to increase levels of resistance, and crossed to western cultivars or breeding lines with superior horticultural characteristics (3, 4, 5). Progeny of crosses made at Prosser and by breeders at Aberdeen, Id., and other locations have been tested and retested in severe disease and stress nurseries that screen out only the most resistant for subsequent evaluation. For the past few years these have been evaulated for productivity and quality characteristics with and without the use of pesticides (8, 10, 12, 13). In 1990 additional efforts were made to characterize and quantify the resistance of these lines and results are reported herein.

MATERIALS AND METHODS

During the past 4 years the yield, grade, and tuber quality of numerous standard cultivars and several hundred lines with useful levels of resistance have been compared when grown with and without pesticides (disease exposure). Exposure to diseases in crops grown without pesticides was enhanced by interplanting with diseased tubers to provide potato leafroll virus (PLRV) source plants in a current season leafroll (CSLR) nursery, rub inoculating each plant with potato virus Y (PVY) in a current season Y (CSY) nursery, and planting an early dying (ED) nursery in a field heavily invested with Verticillium dahliae. Nothing was done to discourage early blight, powdery mildew, Sclerotinia wilt, or common scab in these three disease nurseries and they also sometimes became severe late in the season on commercial cultivars. To determine effects of chronic virus infections, tubers were saved from cultivars and resistant lines in the CSLR and CSY nurseries, and were planted the following year in chronically infected (ChrLR and ChrY) nurseries.

Symptoms of all observable diseases were subjectively rated on each line at biweekly intervals, starting in early August. Periodically during the growing season each line was serologically indexed (ELISA) for content of PLRV and PVY, plant juices were plated out on agar media to count Verticillium and Colletotrichum black dot propagules, and leaves were collected for aphid counts. The 12 replications of 10 hills of each line planted in each trial were sequentially harvested (7, 11), three replications every 3 weeks from early August through late October. Total yield, marketable yield, and specific gravity were determined and tubers were examined for internal and external defects, bruise susceptibility, storability, and cooking characteristics.

RESULTS AND DISCUSSION

Potato Leafroll Virus

All plants of cultivars currently grown in the Northwest expressed severe leafroll symptoms in the 1990 LR nursery and this caused reductions in yield and grade (data not shown).

In contrast, most multi-resistant lines being evaluated had less severe LR symptoms and suffered minimal or no losses when compared with Russet Burbank (Figs. 5, 2). Quantitative ELISA tests showed plants in resistant lines usually contained PLRV by harvest but virus concentrations were lower than in commercial cultivars (Fig. 6). The resistant lines were usually colonized by fewer aphid vectors (Fig. 11). When tubers from PLRV infected plants were planted as seed the following year, the difference in disease expression and performance between Russet Burbank and resistant lines was extreme (Fig. 12, 13). The crops from Russet Burbank and other Northwest cultivars had little value, while chronically infected resistant lines produced acceptable crops. Current season infection with PLRV produced minimal net necrosis symptoms in tubers of most resistant lines. In contrast, current season infection caused severe net necrosis in Russet Burbank tubers and rendered them worthless.

Potato Virus Y

In some commercial cultivars, current season PVY infection caused defoliation and stunting and often very severe effects (data not shown). ELISA tests showed they contained high levels of PVY. In contrast, Russet Burbank expressed only mild CSY symptoms and the multi-resistant lines had few or no symptoms (Fig. 7), lower numbers of aphid vectors (Fig. 11), and little detectable PVY in ELISA tests (Fig. 8). They produced normal yields, grades, and quality (Fig. 3). Again, the differences were even more dramatic when PVY infected tubers were used as seed (Figs. 12, 13). Chronically infected cultivars, including Russet Burbank, produced few useful tubers while resistant entries produced acceptable yields.

Early Dying

Biweekly monitoring of ED symptoms combined with sequentially harvesting provided an indirect measure of the value of ED resistance. When harvested in September, before or at the time susceptible cultivars were senescing and dying, ED resistant lines produced yields similar to Russet Burbank, but these resistant lines remained healthy and produced larger yields than Russet Burbank in October harvests (Fig. 4). Resistant lines started dying much later (Fig. 9) and were found to have less Verticillium propagules in stems than Russet Burbank (Fig. 10). Very few Colletotrichum propagules were observed in these studies. Resistance to ED is needed before full benefits of PLRV and PVY resistance can be expressed. This ED resistance may be of less value in areas with short growing seasons.

ED resistance is often characterized as "late maturity" though it is not necessarily associated with late tuber setting, bulking, and maturity. Late senescence also often confers resistance to other early dying diseases, like Sclerotinia wilt, early blight, and powdery mildew. However, strong ED resistance can present problems. Large, green plants are difficult to kill and handle during harvest. The skin of tubers from such plants often does not properly "mature" or "set" so is not retained well during harvesting. Moderate levels of early dying resistance will probably be more desirable then levels of resistance that result in large green, actively growing vines at harvest time.

Multi-resistant lines reduce needs for pesticides

Lines with combined resistance to PLRV, PVY, and ED require minimal use of chemicals for insect and disease control. Many appear to be less appealing to Colorado potato beetles and spider mites than Russet Burbank so only occasional sprays with synthetic pyrethroids and acaricides will control Colorado potato beetles and mites. These treatments cause little environmental concern.

Some multi-resistant lines appear to have potential for release as cultivars or breeding parents. These are being rapidly increased and their resistance and horticultural attributes are being evaluated in regional and grower trials. These multi-resistant lines: 1) reduce need for insecticides like aldicarb, 2) reduce environmental contamination, 3) reduce grower costs and losses, 4) increase productivity and tuber quality, and 5) increase profits for growers, packers, and processors.

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Figure 1. Productivity of Russet Burbank and seven multi-resistant lines when they receive standard pesticide applications and minimal disease exposure. Percent U.S. No. 1 yield noted at top of each bar. Identity of lines is: RB = Russet Burbank, 85 = 87Tr2246-1, 134 = AO81235-102, 135 = A81286-1, 167 = A83146-3, 177 = AO8478-1, 178 = AWn84181-9, and 181 = AO84275-3.

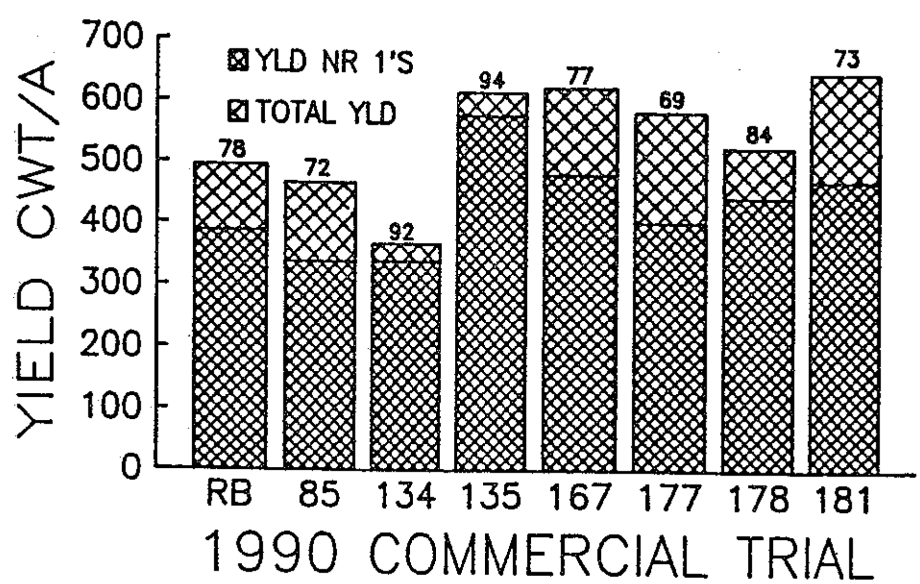

Figure 2. Productivity of lines shown in Fig. 1 when grown in a potato leafroll virus disease nursery, every third row planted with tubers known to be infected with PLRV and no aphicides applied to control PLRV vectors.

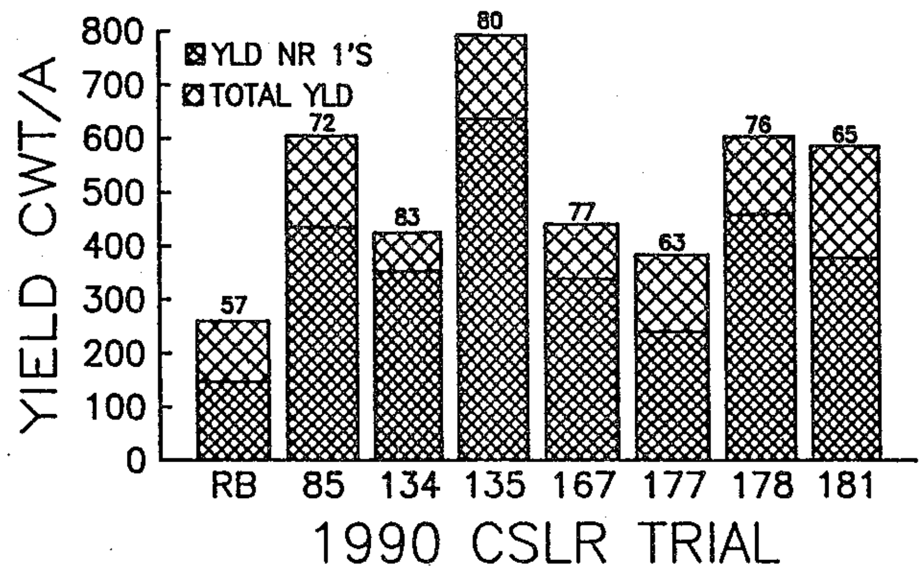

Figure 3. Productivity of lines shown in Fig. 1 when grown in a potato virus Y disease nursery, every plant rub inoculated with PVY inoculum and no aphicides applied to control PVY vectors.

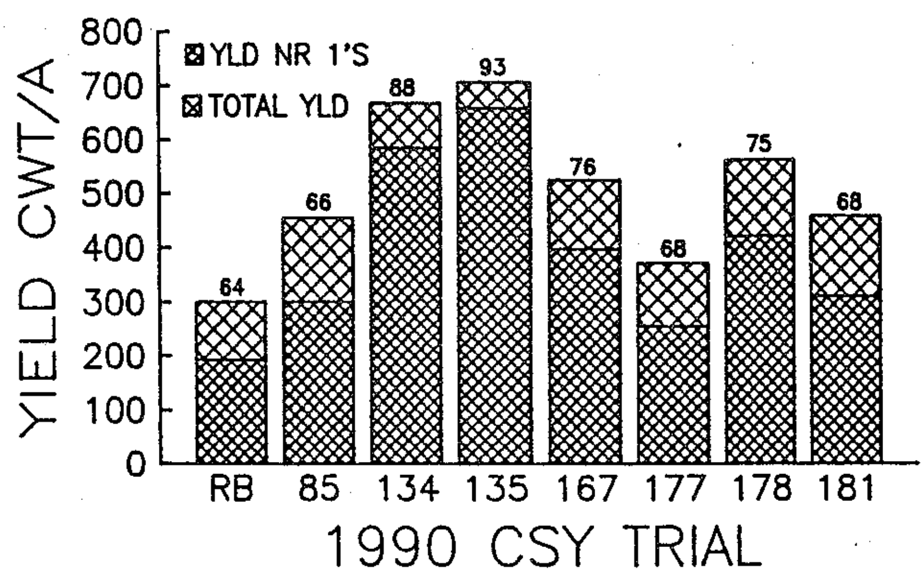

Figure 4. Productivity of lines shown in Fig. 1 when grown in nurseries where exposure to early dying diseases, such as Verticillium wilt and early blight, was very severe. Demonstrates yield advantages of early dying resistant lines in later harvests.

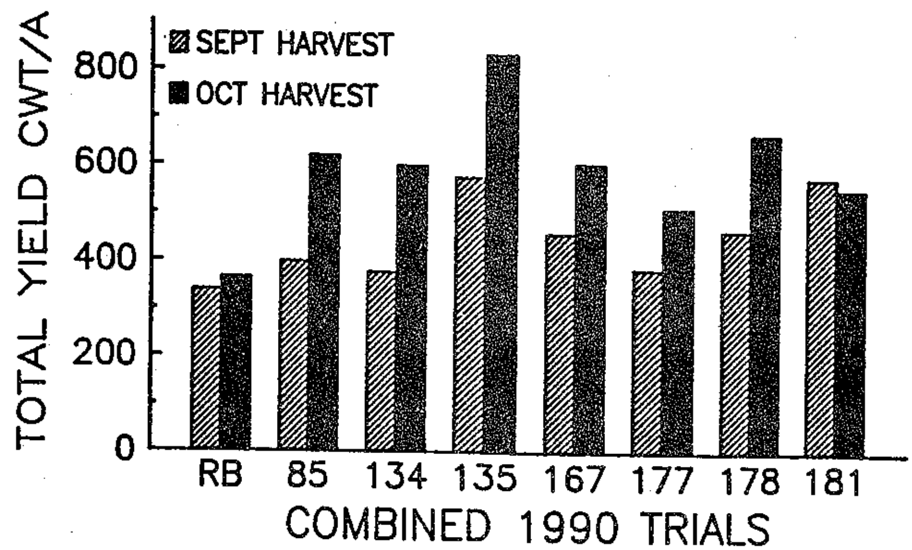

Figure 5. Average disease response ratings of lines shown in Fig. 1 when grown in the PLRV nursery. Rating scale: 0 = no resistance, 5 = no visual symptoms of leafroll disease.

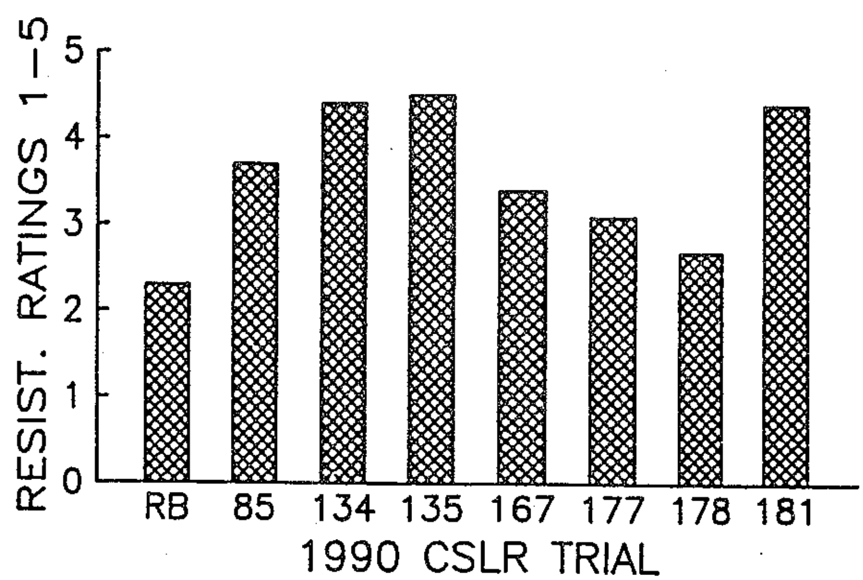

Figure 6. Average ELISA absorbance readings for PLRV when lines shown in Fig. 1 were grown in the PLRV disease nursery.

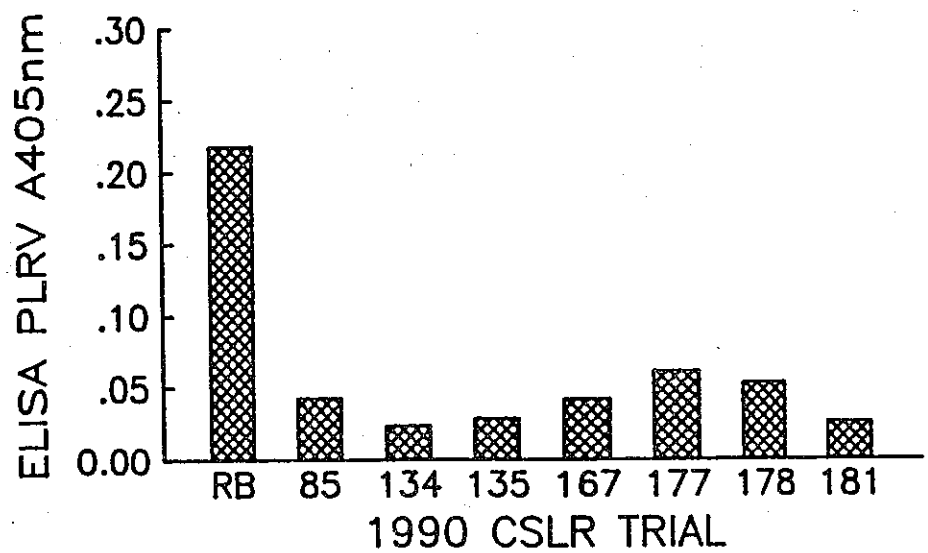

Figure 7. Average mosaic disease response ratings of lines shown in Fig. 1 when grown in a PVY nursery where all plants were hand inoculated with PVY, no application of aphicides. Rating scale same as Fig. 5.

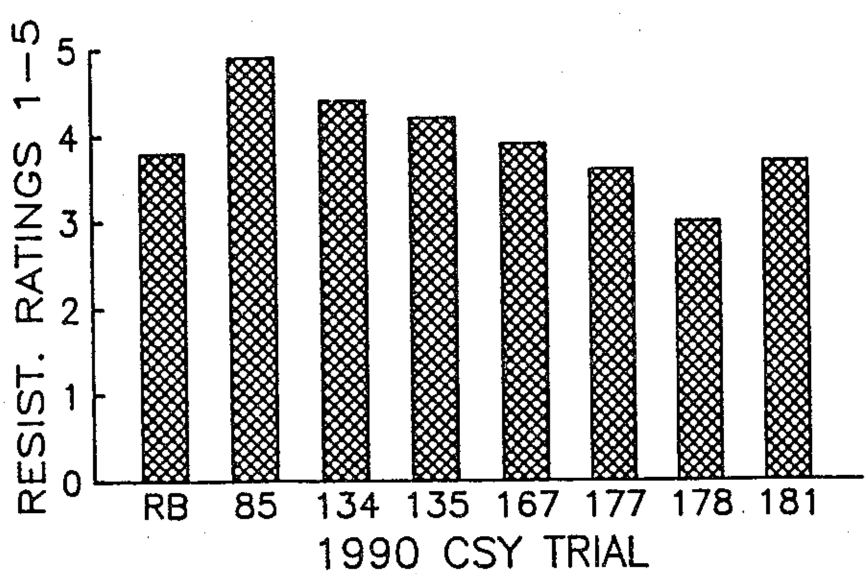

Figure 8. Average ELISA absorbance readings for PVY when lines shown in Fig. 1 were grown in the PVY disease nursery.

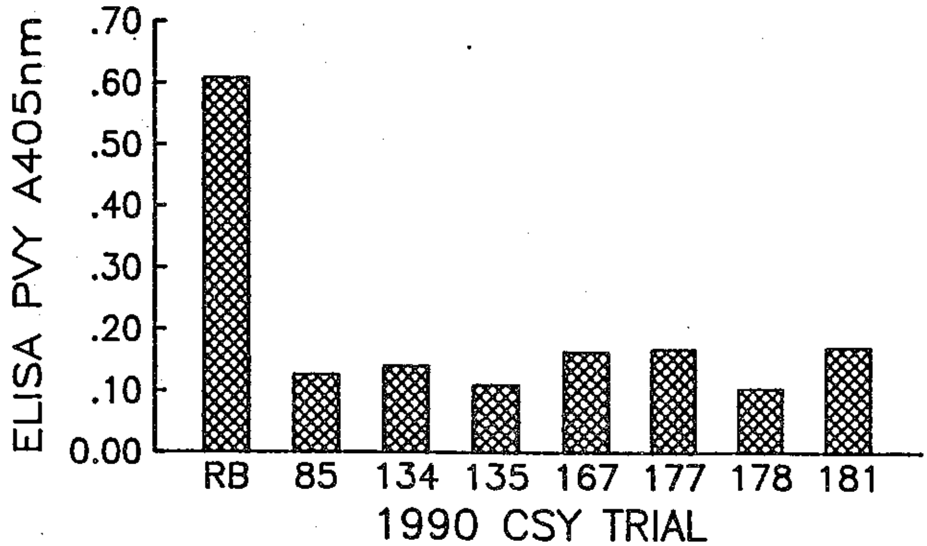

Figure 9. Average disease response rating of lines shown in Fig. 1 when grown in fields previously cropped numerous times to potatoes, thus providing severe exposure to several early dying diseases, no applications of fungicides or soil fumigants. Same rating scale as Fig. 5.

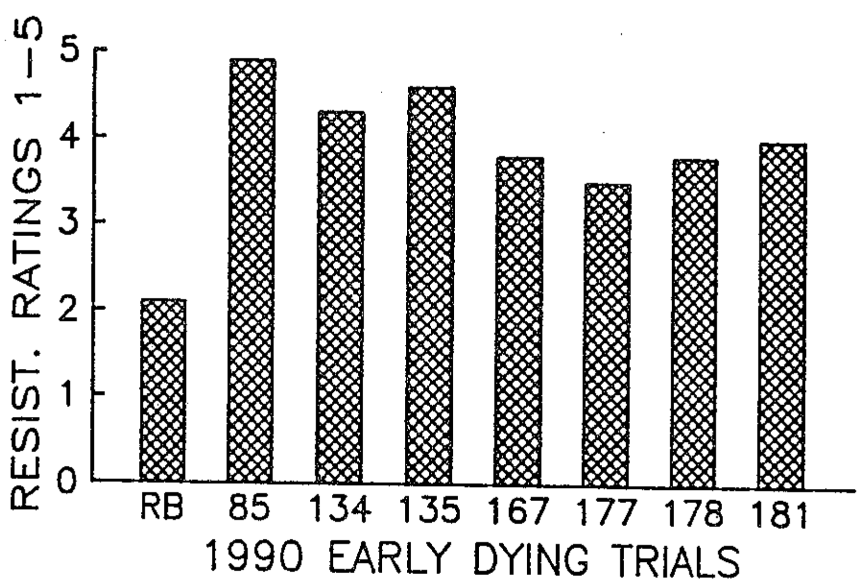

Figure 10. Average number of propagules of Verticillium dahliae in upper stems of plants grown in an early dying disease nursery. Line identifications shown in Fig. 1.

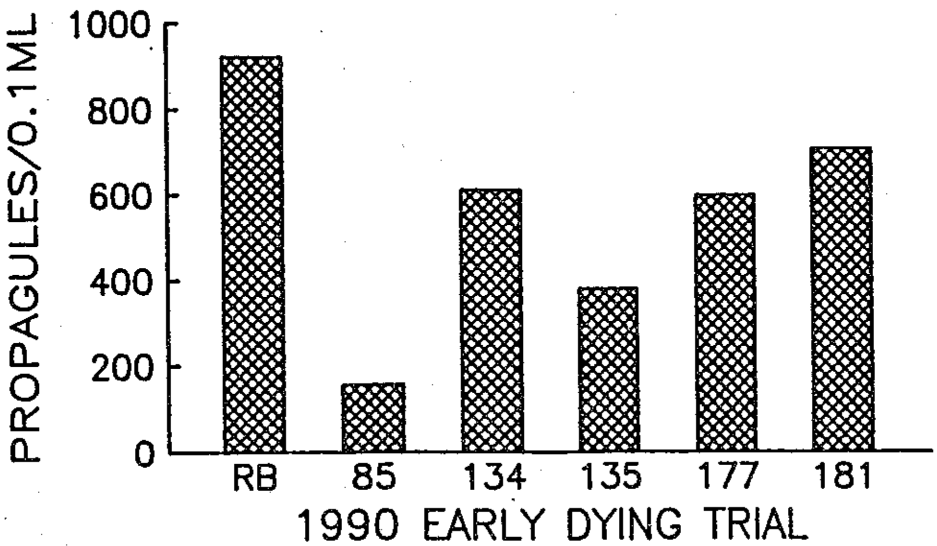

Figure 11. Average number of aphids on leaves of several commercial cultivars and the multi-resistant lines listed in Fig. 1, when grown in PLRV and PVY disease nurseries where no aphicides applied. Identity of cultivars is: NG = Norgold, HL = HiLite, NK = Nooksack, and LE = Lemhi.

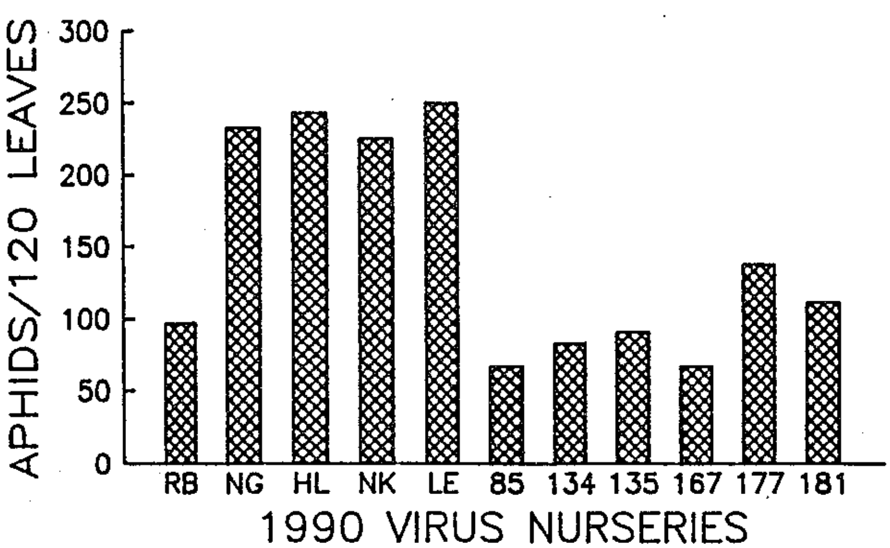

Figure 12. Average leafroll and mosaic disease ratings of Russet Burbank and six multi-resistant lines when grown from tuber seed collected from 1989 virus disease nurseries where all commercial cultivars had been 100% infected. Same ratings scale as Fig. 5. Identity of lines same as shown in Fig. 1 plus 189 = AWn85540-1 and 191 = AWn85542-9.

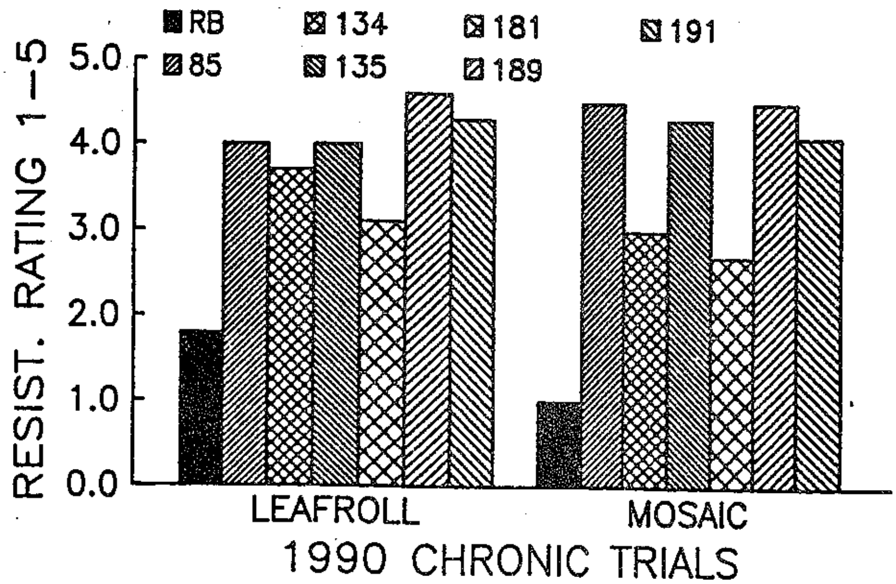

Figure 13. Productivity of lines shown in Fig. 12 when grown in chronic disease nurseries.