In addition to problems with fruit size, growers question the quality of the newly-propagated strains of 'Gala.' Dickinson and White (1) made microscopic examinations of the epidermis and hypodermis of 25 strains of 'Gala' fruit. They found the cells of only 'Regal Gala' had small vacuoles. Fruits of all other cultivars examined had both large and small vacuoles. These data infer that anatomical and physiological differences may exist between 'Regal Gala' and other red sports. Yamaki (5) has suggested that translocated sorbitol is actively compartmentalized in the vacuole during fruit growth to creat the turgor needed for fruit growth. It is possible that the preliminary observations of vacuole size made by Dickinson and White (1), and soluble solids made here may be linked to differences in carbohydrate partitioning and fruit quality between clones.

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In Vitro Testing of the Reaction of Apple Rootstocks to *Phytophthora Cactorum*[1]

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Introduction

Crown rot caused by *Phytophthora cactorum* (Leb. & Cohn.) Schroet. is one of the most important soilborne diseases of apple, *Malus domestica* Borkh., in Washington and throughout the world. The incidence of this disease has increased with the worldwide commercial acceptance of clonal rootstocks. Since Baines (1) first demonstrated that *P. cactorum* was a causal agent of collar or crown rot on apple several other species of *Phytophthora* have also been implicated with the disease (3, 7, 8). Based on field observations plus grower complaints, MM.104 has been the most susceptible rootstock followed in order by MM.106 and M.26. The incidence of crown rot on M.7, MM.111 and seedling was similar and less than on M.26. The disease has been rare on M.9. Much of the disease on seedling is more appropriately termed collar rot in that it involves the scion rather than the rootstock.

Size-controlling clonal rootstocks are highly desirable in modern apple culture and essential for high density orchard systems (5). Experiences with the susceptible clones such as MM.104 and MM.106 point out the importance

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of knowing the susceptibility of new rootstocks before they are widely planted. Browne and Mircetich (3) have simulated crown rot symptoms on seedling apple with several species of *Phytophthora*. The problem with using their technique with clonal rootstocks is the difficulty of obtaining plant material that is not contaminated with *Phytophthora spp* (7). Currently the methods commonly used to evaluate the interaction of pathogen and rootstocks (2, 8) including the method used in this study involve wounding prior to inoculation. Such techniques only measure the susceptibility of the phloemcambium region (PCR) to the ingress of the pathogen and thus ignore resistance to the penetration of bark.

This study was undertaken to determine the reaction of the PCR to *P. cactorum* with some of the newer clonal rootstocks that are now or will soon become available for commercial planting.

Materials and Methods

In April 1983 and 1984 twenty rooted plants of each apple rootstock (Table 1) taken from nursery stool beds were planted in a randomized block design on nonfumigated orchard soil at the Columbia View orchard of the Tree Fruit Research and Extension Center. Planting distances were 0.30 x 0.91 m. Weeds were controlled with glyphosate.

Susceptibility to *P. cactorum* was evaluated the year following planting. Inoculations were made in vitro according to the method of Borecki and Millikan (2). In April and in June of both years the basal portions of 10 shoots per rootstock were removed from the field and cut into upper and lower 8 cm sections. Bark was carefully removed and the sections were placed into an incubation chamber consisting of a 10 cm petri dish with moist filter paper inside on the top and bottom. An inoculum plug was placed on the center of each rootstock section and incubated at 26°C. Two cultures of *P. cactorum*, 101 and 1844, were used in this test. Cultures were increased on potato dextrose agar and inocula consisted of a 5 mm plug cut from the advancing margin of the colony.

Evaluations were made at 72 hrs by measuring the length of the discolored PCR resulting from the interaction of the tissue and the fungus. Data were analyzed by ANOVA with separation of means from the susceptible MM.106 EMLA by t test.

Results and Discussion

Neither fungal isolate nor shoot position (upper or lower section) signifi-

Table 1. Influence of apple rootstock on *P. cactorum* lesion length (mm).

	1984		1985	
	April	June	April	June
MM.106	38	53	41	34
MAC-24	41	51		
Domestic Seedling	34°[z]	56		
Antonovka 313			44	28
Budagovsky 490			42	29
P 1			41	29
MAC-1			39	30
Cornell-Geneva 10			44	25°
M.4			38	28
M.7	32°	50	36	28
Ottawa 3	36	41°		
M.9 EMLA	29°	38°	41	25°
P22			35	22°
C6		29°	26	
Cornell-Geneva 24			32°	23°
MAC-39			30°	21°
Budagovsky 9			29°	22°
Mark (MAC-9)	31°	37°	29°	18°
M.26	15°	45	20°	28
P 2			25°	22°

[z]Means within a column followed by an ° are significantly lower than means of MM.106 (P = .05).

cantly influenced lesion length and therefore data for these factors were combined. The differences between rootstocks, however, were highly significant (Table 1). In the 1984 tests two rootstocks, M.9 EMLA and Mark, were less susceptible than MM.106 EMLA in both April and June. In 1985 five rootstocks, Cornell-Geneva 24, MAC-39, Budagovsky 9, Mark and P 2, were less susceptible than MM.106 EMLA in both April and June. Six rootstocks, MAC-24, Antonovka 313, Budagovsky 490, P 1, MAC-1 and M.4, had a level of susceptibility similar to MM.106 EMLA. M.26 EMLA was unique in its behavior, being more resistant in April and comparable to MM.106 EMLA in susceptibility in June of each evaluation year.

Our results with rootstocks that have previously been evaluated generally agree with the earlier observations. The Polish rootstocks P 2 and P 22, as well as the Russian Budagovsky 9, showed considerable resistance in our test, confirming earlier reports (4, 6, 9). MM.106 has been reported to be quite susceptible (4, 10), and M.9 very resistant (4, 6). The apparent high level of resistance of MAC-39, Cornell-Geneva 24 and Mark has not been previously reported.

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I certify that the statements made by me above are correct and complete. L. D. Tukey, Business Manager. September 25, 1989.