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Evaluation of Foreign Peach and Nectarine Introductions in the U.S. for Resistance of Leaf Curl [*Taphrina deformans* (Berk.) Tul.]

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Abstract

Sixty-six U.S. peach and nectarine introductions and six commercial cultivars were visually evaluated for leaf curl infection in the spring in each of 3 years. Most genotypes were moderately susceptible. Twelve plant introductions were highly resistant, some showing no visible symptoms of infection. These genotypes appear to be valuable sources of resistance to leaf curl currently available to peach and nectarine breeders.

Introduction

Leaf curl, caused by *Taphrina deformans* (Berk.) Tul., occurs in most peach and nectarine production areas world-wide particularly in cooler growing regions. The fungus causes early-appearing leaves to become reddish-brown, thickened, and distorted, and to drop prematurely. When large numbers of leaves are affected, heavy defoliation can occur following bloom. This decreases fruit set and can weaken trees. Shoot meristems may be infected causing death of shoots, and summer infections can occur (5). The disease can generally be controlled by a fall fungicide application during dormancy or a spring fungicide applied before bud swell. In areas of high disease pressure both a fall and spring fungicide application may be necessary. While fungicide applications generally control leaf curl, alterations in the spray schedule or the occurrence of unusual conditions favoring infection (5) can cause moderate to severe damage.

Several studies have evaluated the susceptibility of peaches and nectarines to leaf curl. Differences in susceptibility have been reported, but cultivars rated as resistant in one study have not necessarily been rated as resistant in other studies. In most cases trees have been evaluated for only 1 year (1, 4, 5, 6, 8). A four-year evaluation of commercially available cultivars in Italy did not identify resistant genotypes (7). Where resistance has been identified it appears to be moderately to highly heritable (3, 6).

The following study was conducted to evaluate the susceptibility of the U.S. plant introduction accessions to leaf curl over several years. The identification of highly resistant types which could be used in peach and nectarine breeding programs was of particular importance. The susceptibility of many of these accessions was evaluated in 1953 by Ackerman (1). The present study evaluated many of the same, plus additional genotypes, for 3 years.

Materials and Methods

Trees were planted in 1981 as single tree replications in 3 separate blocks at a spacing of 6 x 6m (a few genotypes had only 2 blocks). In 1981 and 1982 Lorsban was applied for control of peach tree and lesser peach tree borers. Herbicides were used to maintain a 2 meter wide weed free strip in the tree rows. No other sprays were applied in these blocks. Trees were trained to an open center form during the first few years of growth, then maintained by mechanical pruning in the dormant season.

Infection was evaluated in the spring of 1985, 1989 (years of high infection pressure), and in 1990 (low disease

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pressure). Trees were scored using the 0-5 system developed by Ackerman (1) with 0 = no visible signs of leaf curl; 1 = up to 20% of leaves exhibiting some symptoms; 2 = 21-40% of leaves with symptoms; 3 = 41-60%, 4 = 61-80%, and 5 = 81-100% of leaves with symptoms (Fig. 1). Ratings also relate to infection severity since trees with low ratings invariably expressed mild symptoms, while high ratings expressed more severe symptoms of leaf distortion, affecting larger areas of leaf surface.

Results and Discussion

There was a wide range of variability in reaction to natural leaf curl infection between genotypes (Table 1). Maximum variation between trees of an individual genotype in one year was generally one level on the rating scale. Greater variation occurred between years presumably due to differences in disease pressure. Overall severity of infection was significantly different between years (P = 0.05) with a mean score of 2.7 in 1985, 2.0 in 1989 and 1.3 in 1990. There was a significant correlation ($r = .7$; $\rho = 0.01$) (2, 9) between the ranking of cultivars in 1985 and 1989, but not between these years and the 1990 ranking. Low infection levels in 1990 caused many cultivars to appear less susceptible in 1990 than in 1985 or 1989, altering the ranking of cultivars for 1990. This suggests that field evaluations of leaf curl are more accurately done in years of elevated infection levels. Trees with an overall rating of 0 to 1 were highly resistant with some showing no sign of infection. Trees with a score of 3.0 or above were severely affected if left unsprayed (Fig. 1). Genotype infection ratings, at the low (0-1) and high (3-5) range, were similar to those of Ackerman (1), for the same genotypes [$r = .78$ ($P = .001$)].

Commercial cultivars included in this study were all moderately susceptible, with 'Harbelle,' and 'Elberta' being the least susceptible (rating 1.4 and 1.6 respectively), 'Loring' and 'Sunhigh' were the most susceptible (rating 2.6 and 2.8 respectively). 'Redhaven' and 'Reliance' rated 2.1 (Table 1). The susceptibility of these genotypes was in general agreement with other reports (1, 4, 6) with the exception of 'Elberta,' which was rated as less susceptible in this study than in other studies.

Figure 1. Peach leaf curl symptoms corresponding to a rating of 2(a), 3(B), and 4(C).

Neither highly resistant nor highly susceptible genotypes had a common country of origin although 4 of the 13 most resistant types (rating 0-1) were from Germany. In comparison, 2 of the most susceptible and 2 of the most resistant genotypes were from China ('Eagle Beak' and 'Pi Tao' vs 'Tos China 1' and 'Tzim Pee Tao' (Table 1).

Table 1. Mean rating[1] of leaf curl susceptibility over three years 1985, 1989, and 1990, Kearneysville, WV.

	PI number	Origin	3 year mean	1985	1989	1990	Ackerman 1953
Baladi 1	82413	Palestine	0	0	0	0	
Tzim Pee Tao		China	0.2	0	0	0.5	—
Rheingold	132007	Germany	0.3	1.0	0	0	0
Proskauer	130980	Germany	0.6	0.7	0	1.0	1
Royal George	151158	Argentina	0.6	0.7	0.3	0.7	1
Genovese	105362	Italy	0.7	1.0	0	1.0	1
Erica Rudolph	132739	Germany	0.9	1.0	1.5	0.3	—
Rogani Gow	113452	USSR	0.9	0.7	1.0	1.0	2
Giallona di Papigno	102521	Italy	1.0	3.0	0	0	1
G.X.	132741	Germany	1.0	1.0	1.0	1.0	0
Tos China 1	77876	China	1.0	2.0	1.0	0	2
Yennoh	78513	USSR	1.0	2.0	1.0	0	0
Precoce D'Ampius	101835	Morocco	1.3	2.0	1.0	1.0	0
01370	117679	USSR	1.3	2.0	1.5	0.5	2
Harbelle		Canada	1.4	2.3	1.3	0.7	—
Elberta		USA	1.6	2.0	1.7	1.0	2
Pollardi	113650	Italy	1.6	1.7	1.7	1.3	0
Soleil d'Octobre	104287	Morocco	1.6	3.0	1.0	0.7	2
Herholdt's Nooiens	133987	S. Africa	1.7	2.0	1.0	2.0	1
Terzarola Col Pizzo	78544	Italy	1.7	0	3.0	2.0	3
Bienvenida	101823	Morocco	1.7	3.0	2.0	0	1
Inkoos	93826	S. Africa	1.7	3.0	2.0	0	1
Killiekrankie	106062	S. Africa	1.7	2.0	1.0	2.0	4/5
Lucker Busser I	132743	Germany	1.7	3.3	1.0	0.7	1
China Flat	125025	India	2.0		3.0	1.0	5
Hsueh Tao	72094	China	2.0	3.0		1.0	4
Ta Tao 1	101663	China	2.0	3.0	2.5	0.5	1
Redhaven		USA	2.1	3.0	1.7	1.7	2
Reliance		USA	2.1	3.3	1.7	1.3	—
Ta Tao 24	101686	China	2.1	3.3	2.0	1.0	1
USSR Sel. Seedling	146137	USSR	2.2	4.0	1.7	1.0	—
Chui Hun Tao		China	2.2	3.7	2.0	1.0	—
Pineapple[2]	131209	England	2.2	3.0	2.5	1.0	0
Ta Tao 7	101669	China	2.2	3.3	2.3	1.0	1
Gaschina Novembre	104488	Italy	2.3	4.0	1.7	1.3	2
Bolivian Cling	36126	Bolivia	2.3	3.0	2.3	1.7	5
Chinese Cling		China	2.3	3.5	2.5	1.0	—
Khidistavsky	119836	Turkestan	2.3	3.5	3.0	0.5	2
Ta Tao 2	101664	China	2.3	3.7	2.3	1.0	1
Ta Tao 20	101682	China	2.3	3.5	2.3	1.0	1
Ta Tao 3	101665	China	2.3	3.0	3.0	1.0	1
Turnip-shaped	119840	Turkestan	2.3	3.5	3.0	0.5	3
Violette Hative[2]	131075	France	2.3	4.0	2.0	1.0	2
Hangchow		China	2.4	3.3	2.7	1.3	—

Table 1. (Continued).

	PI number	Origin	3 year mean	1985	1989	1990	Ackerman 1953
Saharanpur 2	112033	India	2.4	3.3	3.0	1.0	4
Herholdt's Late Cling	133982	S. Africa	2.5	4.0	3.0	0.5	3
Marina	133984	S. Africa	2.5	4.0	3.0	0.5	3
P.H. 3002		USA	2.5	3.5	3.5	0.5	—
Ta Tao 27	101687	China	2.5	4.0	2.5	1.0	2
Ta Tao 6	101668	China	2.5	4.5	2.0	1.0	1
Yunnan	55776	China	2.5	3.5	3.0	1.0	3/4
Loring		USA	2.6	3.0	2.7	2.0	—
Kakamas		S. Africa	2.7	3.5	3.0	1.5	—
Ku Chua Hung 14	101676	China	2.7	4.0	3.0	1.0	1
Sel. Seedling	134050	Spain	2.7	3.0	3.0	2.0	2
Ta Tao 5	101667	China	2.7	4.0	3.0	1.0	1
Darwin[2]	131430	England	2.8	2.0	3.0	3.3	1
Sel. Seedling	134401	China	2.8	4.0	3.3	1.0	3
Sunhigh		USA	2.8	4.0	3.0	1.3	3
Aguas 12-13		Mexico	2.9	4.7	3.3	0.7	—
Spathe deHallen	131034	Germany	2.9	4.0	2.7	2.0	3
Ingwe		S. Africa	3.0	4.0	3.0	2.0	—
Mexican Honey		Mexico	3.0	4.0	4.0	1.0	—
Angel	129674	S. Africa	3.1	3.7	4.0	1.7	5
Eagle Beak	43289	China	3.2	4.5	6.5	1.5	3/4
Platycarpa	119846	Turkestan	3.3	4.3	3.0	2.7	5
Shalil	63850	India	3.3	5.0	3.0	2.0	5
Pi Tao	62602	China	3.4	3.7	3.0	2.0	2
Nishiki		Japan	3.5	5.0	3.5	2.0	—
Aguas 6-4		Mexico	4.3	5.0	4.0	4.0	—
Prunus mira	34601		4.5	4.7	4.0	4.7	—
Ferganensis 02446	113455	USSR	4.7	5.0	4.0	5.0	4

[1]Visual ratings, 0 = no visible signs of leaf curl; 1 = up to 20% of leaves exhibiting some symptoms; 2 = 21-40% of leaves with symptoms; 3 = 41-60%; 4 = 61-80%; 5 = 81-100% of leaves with symptoms.
[2]Nectarine.

While an association between the absence of leaf glands and resistance to leaf curl was reported by Ackerman (1), the association was not strong. In the present study, of 12 of the most resistant genotypes (rating 0-1), 3 were glandless. Of 12 of the most susceptible types (rating 3-5), none were glandless. While the absence of glands may be an indication of resistance, the presence of glands does not prelude resistance.

Ackerman (1), working in a lower chill unit accumulating environment, suggested a relationship between time of leafing out of a genotype in the spring and leaf curl infection based upon climactic conditions during the initiation of leaf growth. There was little apparent difference between genotypes in time of leafing out in the spring under the climactic conditions prevalent during the 3 years of this study. Although small, unobserved differences in the time of leafing out could have had an influence on infection severity by exposing developing leaf tissue to *T. deformans* at a time more or less favorable to infection.

The results of this study indicate that high levels of resistance to leaf curl are available in peach germplasm, particularly in germplasm not currently commercially utilized. If resistance is highly heritable, as has been suggested (3), the development of leaf curl resistant cultivars is a viable goal for peach breeding programs.

Factors such as climate, particularly during leaf development in the spring, and inoculum density may affect field evaluation of leaf curl resistance requiring multiple years of observation. The development of controlled inoculation procedures would aid in the evaluation of resistance in both exotic germplasm and seedling progeny and reduce the time necessary to develop resistant cultivars.

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Breeding Apples for Scab Resistance: 1945-1990

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Abstract

The breeding of apples resistant to scab incited by *Venturia inaequalis* (Cke.) Wint. is a genetically-based strategy for the control of this major fungal fruit pathogen. A concerted breeding effort began with three cooperating Agricultural Experiment Stations in the late 1940s and early 1950s. Soon afterwards collaboration was extended to research workers in Canada and Europe, and later to other continents. The effort that continues today in at least 17 breeding programs throughout the world was based on a modified backcross program to combine genes for resistance to apple scab from *Malus floribunda* 821, and other species with commercially-accepted traits. Since 1970, 48 scab-resistant cultivars have been released worldwide of which 37 purportedly carry the V_f gene from *M. floribunda* 821, one of which ('Freedom') carries additional polygenic resistance from 'Antonovka,' one ('Imrus') with V_f from *M. atrosanguinea* 804: five with other genes [one ('Rouville') with the V_m gene from *M. atrosanguinea* 804; one ('Nova Easygro') with the V_r gene from a Russian apple seedling from the Caucasas Mountains (R#12740-7A); one ('Murry') with V_m and/or V_f from *M. micromalus;* and three ('Romus 2,' 'Gavin' and 'Generos') with polygenic resistance only. There now exists a wide range of genotypes containing the V_f gene ranging in maturity from 75 days to 180 days or longer after flowering, with large fruits, crisp flesh, good storage behavior, and a wide range in flavor and skin color. A number of selections have been identified that contain varying degrees of resistance to other diseases and pests.

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