J. Turk. Phytopath., Vol. 37 No. 1-3, 27-37, 2008 ISSN 0378 - 8024

Susceptibility of Some Peach and Nectarine Varieties to Leaf Curl Disease (*Taphrina deformans* (Berk.) Tul.) in Field Conditions

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Accepted for publication March 1, 2011

ABSTRACT

Leaf curl, caused by *Taphrina deformans*, is a serious disease on peaches and nectarines. Heavily infected fruit trees are poorly nourished, develop fewer flower buds, and are more easily damaged from freezing in winter. To prevent these negative effects, the best approach is to breed and grow cultivars genetically resistant to the pathogen. In this research, susceptibility of 82 peach and 22 nectarine varieties to leaf curl disease was investigated in ecological conditions of Isparta province in 2003 and 2004. Disease severity was calculated by the 0-5 scale when typical symptoms of leaf curl were evaluated on peach and nectarine leaves in naturally infected orchards.The conditions of natural infection allowed grouping the biological material in 4 classes (plant growth stages) and 6 groups of resistance for leaf curl disease severity. The results indicated that early varieties; 'Sun High and Tejon', middle early variety; 'Flour Dasun', middle season variety; 'Shesta' and late varieties; 'Andros, Muir and Red King' were determined as highly susceptible. All of the early nectarine varieties, middle early varieties; 'Crimson Cold, Independence and Spring Red', middle season varieties; 'Nec-8, Stark Red Gold and Nec-6' and late variety 'June Berta' were found as susceptible varieties.

Key Words: Leaf curl, nectarine, peach, resistance, *Taphrina deformans*

INTRODUCTION

Peaches (*Prunus persica*) and nectarines (*Prunus persica* var. *nucipersica*) are among the most important fruit crops of temperate climates. Peach breeding worldwide is very intensive and more than 6000 cultivars are cultivated (Ognjanov et al., 1993). According to FAO data of 2008 year, peach and nectarine production is about 18.000.853 t and Turkey is taken part sixth place with 551.906 t productions in the world (Anonymus, 2010a).

Taphrina deformans (Berk.) Tul. is a biotrophic parasitic fungus that causes leaf curl the disease reduces significantly yield and tree longevity on both crops (Pscheidt, 1995). *T. deformans* has a dimorphic life cycle, with a parasitic and a saprophytic phase (Agrios, 1988). The parasitic phase starts when spores, in young host tissues by producing a hypha that penetrates the cuticle and invades the host tissue between the epidermal and the parenchyma cells (Mix, 1935). The parasitic phase culminates with the homothallic production of a compact, feltlike layer of naked asci erupting from the cuticle (Mix, 1949; Bassi et al., 1984). Rainy and warm weather in the beginning of leaf emergence creates optimal conditions for the spreading of the disease. Symptoms are visible on the young leaves at the beginning of the growth (Ninkovski, 1988). Infected peach leaves are deformed (curling), died and falled of in early season. The fungus causes the whitish bloom that covers infected leaves during infection progresses. This color is made of asci that break through the cuticle of the leaves Anonymus, 2010b). Twigs may show signs of disease, such as being black in color and swollen. Fruit can be affected, showing a reddish color (Chester, 1947; Anonymous, 2008). Variations in disease occurrence in peach producing areas of world are related to meteorological factors. Reports from different peach-growing areas show that leaf curl disease occurs only when repeated rainfall coincides with low temperature during early bud development (Manaresi, 1915; Anderson, 1956; Agarwala et al., 1966; Molnar, 1967; Westwood, 1993). The fungus has higher infection rates following cooler winters and economical losses are reached to decrease of yield about 100% (Kansu, 1995; Smith, 2009).

Plant disease resistance derives from both pre-formed defenses and infection-induced responses mediated by the plant immune system. Relative to a disease-susceptible plant, disease resistance is often defined as reduction of pathogen growth in the plant, while the term disease tolerance describes plants that exhibit less disease damage despite similar levels of pathogen growth. Plants are almost resistant to certain pathogens but susceptible to other pathogens; resistance is usually pathogen species-specific or pathogen strain-specific (Lucas, 1998; Hammond-Kosack and Jones, 2000). There is a range of susceptibility to peach leaf curl in present grown peach and nectarine cultivars. Pejkic (1980) and Misic (2002) cited that the lower susceptibility to leaf curl is one of the goals of the peach breeding. Obtaining data will be provided hopeful results to the disease in organic agriculture and integrated programs.

The aim of this study was to investigate the reactions of commercial peach and nectarine varieties to leaf curl disease in field conditions.

MATERIALS and METHODS

Plant Material

To determine the susceptibility of peach and nectarine varieties to peach leaf curl disease, 7-9 year old 82 peach and 22 nectarine varieties were used in the field,

adaptation orchards of Horticultural Research Institute of Egirdir, Isparta, in 2003 and 2004 years. The varieties used in the experiment were shown in Table 1, 2 and 3.

Classification of Peach and Nectarine Cultivars

Peach and nectarine cultivars were classified according to fruit ripening periods (Guven et al., 2003) as stated below:

Early Varieties : fruit ripening until 15th July
Middle Early Varieties : fruit ripening between 15th July and 1st August
Middle Season Varieties : fruit ripening between 1st August and 1st September
Late Varieties : fruit ripening after 1st September

Experimental Design

Disease evaluations were made in the orchards in which the disease was observed in the previous years. Evaluations of the disease were made according to its microscopic and macroscopic properties (Agrios, 1988; Anonymous, 1996). Typical symptoms of leaf curl were screened on upper leaves of shoots and any leaf bearing macroscopic symptoms accepted as an infected leaf. When growing of the disease stopped, diseased and healthy leaves were counted. Five shoots were randomly selected from reverse four sides (east, west, south and north) of a tree were determined and the infected leaf numbers for each shoot were counted on the upper five leaves. The experiment was designed a full factorial arrangement of treatments in a completely randomized block design with 5 repetitions. Totally a hundred leaves, infected and healthy, at the five shoots of one tree were counted as one repetition (Duzgunes et al 1987). Disease ratio (%) was calculated by proportion of infected leaf number to total leaf number. The susceptibility levels of peach and nectarine varieties were determined by the 0-5 scale using percent disease ratios (Ivascu et al., 2000);

Scale Classes	Disease Ratio (%)	Susceptibility Levels
0	no symptom	Immun (I)
1	0,1 – 3	High Resistant (HR)
2	3,1 – 10	Resistant (R)
3	10,1 – 25	Middle Resistant (MR)
4	25,1 – 50	Susceptible (S)
5	50,1 – 100	High Susceptible (HS)

Data Analyses

The arithmetic mean of disease severities was calculated for two years and all statistical analyses were performed using MINITAB (State College, PA, USA) and

MSTAT software (Michigan State University, MI, USA) and the differences between treatments were determined by Least Significant Difference (LSD) Test ($p< 0.05$).

RESULTS

In this research, the susceptibility of some peach and nectarine varieties to leaf curl disease (*T. deformans*) was investigated in ecological conditions of Egirdir, Isparta. The means of 2003 and 2004 findings were given at the following headings.

Susceptibility of Peach Varieties to the Disease

Early varieties

The varieties of Sun High and Tejon were found to be highly susceptible, Spring Crest, Rich Haven, Spring Lady, Spring Time, Early Red, May Crest, Blazing Gold and Early Red Free were as susceptible, Morettini 5114, Rochon and Cardinal were as middle resistant and Precocissima were as high resistant against leaf curl (Table 1).

Table 1. Susceptibility Classess of Early and Middle Early Peach Varieties to Leaf Curl Disease (*Taphrina deformans*)

Period	Variety	Disease Ratio (%)	Reaction Class	Period	Variety	Disease Ratio (%)	Reaction Class
Early Varieties				Middle Early Varieties	Flour Dasun	70,29a	HS
					Jerseyland	48,64b	S
	Tejon	63,5a**	HS*		Flover Crest	44,5bc	S
	Sun High	59,43b	HS		Sun Red	44,43bc	S
	Spring Time	44,57c	S		Merill Gem Free	40,14d	S
	Spring Crest	40d	S		May Gold	39,69de	S
	Spring Lady	40d	S		June Gold	35,07f	S
	May Crest	35e	S		Red Cab	33f	S
	Ric Haven	33,86ef	S		E. White Giant	32,43f	S
	Early Red Free	32,64eg	S		Cortez	29,36fg	S
	Blazing Gold	31,43eg	S		Gold Dust	26,93g	S
	Early Red	26,29h	S		Starking Delicious	26,5g	S
	Morettini 5114	24,14hi	MR		Keystone	26,36g	S
	Rochon	20.07j	MR		Dixigem	23,07gh	MR
	Cardinal	15,14k	MR		Coronet	22,07h	MR
	Precossima	0,21l	HR		Red Haven	19,43h	MR
					Dixi Red	18,29hi	MR
					Red Tab	16,79i	MR

* HR: High Resistance, R: Resistance, MR: Middle Resistance, S: Susceptible, HS: High Susceptible

** The differences between treatments were determined by Least Significant Difference (LSD) Test at $p < 0.05$ level.

Middle early varieties

Flour Dasun was determined to be highly susceptible, Flover Crest, Jerseyland, May Gold, Merill Gem Free, June Gold, Sun Red, Red Cab, Gold Dust, Starking Delicious, Keystone, E. White Giant and Cortez were susceptible, and Dixigem, Coronet, Red Haven, Dixi Red and Red Tab were middle resistant (Table 1).

Middle season varieities

In the middle season peach varieties, Shesta was found as high susceptible, Elegant Lady, Ventura, Trio Gem, Merill 49, Maima Rose, Ranger, Red Globe, Washington, July Elberta, Golden Jubile, Sun Crest, Loring, Lovel and Fortuna were susceptible, Glo Haven, Hale Haven, South Haven, Fair Haven, Vivian and Vesiuo were middle resistant, and Sapanca and Edirne were resistant against *T. deformans* (Table 2).

Table 2. Susceptibility Classess of Middle Season and Late Peach Varieties to Leaf Curl Disease (*Taphrina deformans*)

Period	Variety	Disease Ratio (%)	Reaction Class	Period	Variety	Disease Ratio (%)	Reaction Class
Middle Season Varieties				Late Varieties	Andros	71,93a	HS
					Muir	65,64b	HS
	Shesta	67,57a**	HS*		Red King	65b	HS
	Elegant Lady	47,71b	S		Elberta Giant	48,07c	S
	Merill 49	42,36b	S		Jefferson	43,86d	S
	Ventura	41,5b	S		Blake	42,43d	S
	Red Globe	41,21b	S		Elberta	42d	S
	Trio Gem	39,43bc	S		Carolyn	41,43de	S
	Washington	38,21c	S		Rio Oso Gem	39,43e	S
	Fortuna	35,64cd	S		Madison	38,5ef	S
	July Elberta	31,64e	S		Fawler	35,36g	S
	Golden Jubile	30,71e	S		S. Late Red	33,36g	S
	Loring	29,07ef	S		Monroe	33,36g	S
	Sun Crest	27,29ef	S		İsfahan Yarması	30,07h	S
	Maima Rose	27,14ef	S		Yeşil Türbe	29,64h	S
	Ranger	26,93f	S		Honey Dew Tree	29,14h	S
	Lovel	25,71f	S		J. H. Hale	28,93h	S
	Vesiuo	24,5fg	MR		Takınyacı 7	24,93i	MR
	Glo Haven	22,57fg	MR		Takınyacı	19,43j	MR
	Fair Haven	22,43fg	MR		Alyanak Hulu	18,5j	MR
	Hale Haven	20,29g	MR		Crest Haven	14,5k	MR
	Vivian	20,29g	MR		Sarı Papa	12,36kl	MR
	South Haven	15,5h	MR		Sarı Hulu	12,29kl	MR
	Sapanca	5,86i	R		Kız Memesi	10,86l	MR
	Edirne	4,71i	R		Uzunoğlu	3,5m	R
					Jerdnimo	2,93m	HR
					Nemaquard	1mn	HR

* HR: High Resistance, R: Resistance, MR: Middle Resistance, S: Susceptible, HS: High Susceptible

** The differences between treatments were determined by Least Significant Difference (LSD) Test at $p < 0.05$ level.

Late varieties

Andros, Muir and Red King were determined to be high susceptible, Elberta Giant, Elberta, Blake, Jefferson, Madison, Carolyn, Fawler, Rio Oso Gem, J. H. Hale, Isfahan Yarması, Honey Dew Tree, Yesil Turbe, Monroe and S. Late Red were susceptible, Takinyaci, Takinyaci 7, Alyanak Hulu, Crest Haven, Sari Hulu, Sari Papa and Kiz Memesi were middle resistant, Uzunoglu was resistant, and Jerdnimo and Nemaguardwere high resistant (Table 2).

Susceptibility of Nectarine Varieties to the Disease

All of the early nectarine varieties, middle early varieties 'Crimson Cold, Independence and Spring Red', middle season varieties 'Nec-8, Stark Red Gold and Nec-6' and late variety 'June Berta' were determined as susceptible varieties to leaf curl disease (Table3).

Table 3. Susceptibility Classess of Early and Middle Early, Midle Season and Late Nectarine Varieties to Leaf Curl Disease (*Taphrina deformans*)

Period	Variety	Disease Ratio (%)	Reaction Class	Period	Variety	Disease Ratio (%)	Reaction Class
Early Cult.	May Grand	35a**	S*	Middle Season Cultivar	Nec-8	35,5a	S
	Armking	33a	S		Stark Red Gold	31,7a	S
	Early Sun Grand	26.4b	S		Nec-6	26,4b	S
					Summer Super Star	23,3bc	MR
Middle Early Varieties	Crimson Cold	30,9a	S		Nectarose	22,4bc	MR
	Independence	29,4a	S		Cavalier	20,7bc	MR
	Spring Red	27,6b	S		Fantasia	19,4c	MR
	Nec-5	24,2b	MR		Vp-I-52-N	14,4d	MR
	Cherokee	21,8bc	MR		Silver Lode	14,2d	MR
	Nec-4	19,7c	MR	Late Var.	Fairlane	55,2a	VS
	Plumeless	17,5c	MR		Nec-I-II	52,4a	VS
					June Berta	26b	S

* HR: High Resistance, R: Resistance, MR: Middle Resistance, S: Susceptible, HS: High Susceptible

** The differences between treatments were determined by Least Significant Difference (LSD) Test at $p < 0.05$ level.

DISCUSSION

Resistance to peach leaf curl has been noted first by Rivers (1906). No peach or nectarine cultivar was immune to *T. deformans*, but their susceptibilities vary greatly (Ritchie and Werner, 1981). Ritchie and Werner (1981) have reported that nectarines were more susceptible than peaches. They also reported that all nectarine cultivars except Nectared 6 and Lafayette were either susceptible or highly susceptible. We also obtained different susceptibility results from both peach and nectarine varieties.

We observed the large range of percent disease ratios according as susceptibility differences on peaches and nectarines. The predominant symptom was the development of a yellow to red discoloration on the earliest emerging leaves and subsequent leaf drop. Development of these symptoms was very severely on the highly susceptible varieties.

Redhaven and most cultivars derived from Redhaven have been found to be tolerant to peach leaf curl (Ritchie and Wermer, 1981). In the Eastern USA where the leaf curl was commonly seen all of the cultivars were known to be susceptible. However, Red Haven or Red Haven strains were more resistant than Red Skin or Red Skin related strains (Anonymous, 2005a). A significant proportion (25 to 50%) of the progeny of Cresthaven was also found resistant, as were many cultivars (Todorovic and Misic, 1982). Sharma and Badiyala (1994) reported that early blooming and long incubation period owner varieties were more susceptible to the disease. Fideghelli et al. (1983) and Scorza (1992) have identified exotic or unimproved germplasm with high levels of resistance and immunity in peach populations in Italy and USA. Misic (2002) cited that cv. Creshaven and cv. Villa Ada were low susceptibility or tolerance to the pathogen. Nautiyal et al. (1988), asserted that there was a relation between leaf morphology and infection ratio, and they found four resistant peach cultivars as Stark Early Giant, Starking Delicious, World Earliest and Tesia Samisto to leaf curl in India. Guven et al. (2003) recommend for early varieties as May Crest, Early Red and Spring Lady, middle early varieties as June Gold, Dixired, Gold Dust and Red Haven, middle season varieties as Red Globe, Glo Haven, Sun Crest and Elegant Lady on account of botanical properties, yield and market value. In the same study, Crest Haven as middle resistant and J.H. Hale, S. Late Red Monroe as susceptible was defined for the disease. We found that early varieties and Red Globe, Sun Crest, Elegant Lady, June Gold and Gold Dust from middle season varieties were susceptible to the disease within advised peach varieties by Guven et al., (2003) (Table 1 and 2).

In the observations performed on 230 peach and nectarine cultivars, as early peach varieties; ‘Spring Crest’ susceptible, ‘Cardinal’ middle resistant, and ‘Flacara, Loadel, Loring, Dixon 1, Favorita Moretini, June Gold, Armgold and Madeleine Pouyet’ resistant, as middle season peach varieties; Hale Haven and Vesiuo ‘middle resistant’, Loring ‘susceptible’ and Fortuna and Vivian ‘high susceptible’ reaction showed in Southern Romania (Ivascu et al., 2000). Our investigations were given similar results except Vivian variety and we classified this variety as middle resistant.

Peach varieties, ‘Elberta, Halford, Lowell and Rutgers Red Leaf’ in USA and ‘Uzunoglu’ in Turkey, are used rootstock, in respect to germination and full growing properties. However these varieties are susceptible to *Meloidogyne* spp. in sandy soils. Nemaguard variety was suggested as resistant against nematod injury but, it was used as only rootstock. Also, affinity was expressed between varieties and at the same time, was affected cold injury and chlorose. No commercial importance of its fruit was reported

(Eris and Barut 2000; Anonymous 2005b). In our research, Nemaguard was detected highly resistant variety to *T. deformans.* For this reason, Nemaguard was thought as a gene source for improving studies to the disease.

Hybrid varieties of peach and nectarine were examined genetically to *T. deformans* and Bella di Roma, Catherine Sel.1, Golden Jubilee, Redhaven, Hardired, Filip, Frumoasa litoralului, Stark Saturn and Creola were found as resistant varieties (Trandafirescu et al., 2006). Nectarine varieties, Armking, Crimson Gold, Nec-4, Summer Super Star, Fantasia, Stark Red Gold and Fairlane were advised to use for protection from the disease by Guven et al., (2003). According to our results, Armking, Stark Red Gold and Crimson Gold were determined as susceptible and Nec-4, Summer Super Star and Fantasia were middle resistant (Table 3). According to agronomic criteria, while Redhaven, Sweethaven, Redcal, Benedikte and Mireille varieties were suggested, contrarily Weingartenpfirsich Eibesthal, Sunglo, Diamond Princess, Early Devil and Royal Gem varieties was not advised. In addition, Red Robin, Royal Glory and Nectared 6 varieties were detected partially resistant to *T. deformans* and *Monilinia* sp. (Ohlinger et al., 2007).

The elucidation of the genetics of resistance or immunity to peach leaf curl disease will require intensive programs that take into account the variability in virulence of the organism and host pathogen interactions. It appears that the development of leaf curl resistant cultivars may be a feasible and worthwhile goal.

In conclusion, findings from the present work help to provide a better definition of the impotance of host susceptibility on natural infection by *T. deformans*. The observed data may be used to improve resistant varieties to leaf curl disease and/or to pay attention of these varieties within integrated control programs.

ÖZET

Bazı Şeftali ve Nektarin Çeşitlerinin Yaprak Kıvırcıklığı Hastalığı (*Taphrina deformans* (Berk.) Tul.)'na Karşı Arazi Koşullarda Hassasiyeti

Taphrina deformans'ın neden olduğu yaprak kıvırcıklığı şeftali ve nektarinlerin en ciddi hastalığıdır. Hastalığa hassas meyve ağaçları zayıf gelişir, çiçek tomurcukları iyi gelişemez ve kış donlarından çok kolay bir şekilde zarar görürler. Bu negatif etkilerden korunmanın en iyi yaklaşımı patojene genetiksel olarak dayanıklı çeşitler geliştirmek ve yetiştirmektir. Bu araştırmanın amacı Isparta ekolojik koşullarında yetiştirilen bazı şeftali ve nektarin çeşitlerinin *Taphrina deformans*'a hassasiyetlerin belirlenmesidir. Bunun için 2003 ve 2004 yıllarında 82 şeftali ve 22 nektarin çeşidi hastalığa hassasiyet-leri bakımından değerlendirilmiştir. Hastalık şiddeti doğal enfekteli bahçede şeftali ve nektarinlerde tipik hastalık simptomları gözlendiğinde 0-5 skalasına gore hesaplan-mıştır. Doğal enfeksiyon koşullarında yürütülen çalışmada 4 grup da

sınıflandırılan bitkilerde duyarlılık düzeyi 6 farklı seviyede değerlendirilmiştir. Bu sınıflandırma bitkinin gelişim evrelerine ve yaprak kıvırcıklığı hastalığının şiddetine gore yapılmıştır. Şeftali çeşitlerinden erkenci çeşit olan Sun High ve Tejon, orta erkenci olan Flour Dasun, orta mevsim olan Shesta ve geççi olan Andros, Muir ve Red King çeşitleri hastalığa en hassas çeşitler olarak bulunmuşlardır. Erkenci nektarin çeşitlerinin tamamı, orta erkenci nektarin çeşitlerinden Crimson Cold, Independence ve Spring Red, orta mevsim çeşitlerden Nec-8, Stark Red Gold ve Nec-6 ile gecci çeşitlerden June Berta nektarin çeşidi hastalığa hassas çeşitler olarak belirlenmişlerdir.

Anahtar Kelimeler: dayanıklılık, nektarin, şeftali, *Taphrina deformans*, yaprak kıvırcıklığı

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