

Note

Survey on the Occurrence of Apple Diseases in Korea from 1992 to 2000

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In the survey from 1992 to 2000, twenty-eight parasitic diseases were observed in major apple producing areas in Korea. The predominant apple diseases were white rot (*Botryosphaeria dothidea*), Marssonina blotch (*Marssonina mali*), Valsa canker (*Valsa ceratosperma*), Alternaria leaf spot (*Alternaria mali*), and bitter rot (*Collectotrichum gloeosporioides* and *C. acutatum*). Apple scab that reappeared in 1990 after disappearance for 15 years was disappeared again since 1997. A viroid disease (caused by apple scar skin viroid) was newly found in this survey. The five diseases, fire blight (*Erwinia amylovora*), black rot (*Botryosphaeria obtusa*), scab (*Cladosporium carpophilum*), Monochaetia twig blight (*Monochaetia* sp.), and brown leaf spot (*Hendersonia mali*), which had once described in 1928 but no further reports on their occurrence, were not found in this survey. However, blossom blight (*Monilinia mali*), brown rot (*Monilinia fructigena*), and pink rot (*Trichothecium roseum*), which did not occur on apple after mid 1970s, were found in this survey.

Keywords : apple disease, state of occurrence

Although 41 apple diseases including one viroidal, four viral, four bacterial, one nematoda and thirty-one fungal diseases have been described in Korea (The Korean Society of Plant Pathology, 2004), descriptions of some diseases are insufficient and their actual occurrences have not been fully clarified. The survey on apple disease in Korea was initiated by Japanese scientist from 1916 and continued till 1938, and 23 diseases were described (The Korean Society of Plant Pathology, 1998). From 1972 to 1977, surveys on plant diseases were conducted by UNDP, but those on apple diseases were excluded (Chung, 1977). Lee et al. (1993) investigated apple and pear diseases from 1988 to 1992, and Uhm (1998) carried out a survey for apple diseases in Gyeongbuk province for 3 years from 1992 to 1994. Uhm (1998) found 21 diseases among which twelve were normally found in moderately-well managed orchards. As

the pattern of disease occurrence is always changing by agricultural practices or the cultivars used, the detailed survey of apple diseases should be necessary. The authors carried out a detailed disease survey in major apple producing areas throughout the country from 1992. In this paper, the information obtained during 9 years from 1992 to 2000 was reported.

The first survey in 1992 was carried out at 31 apple orchards located at Andong, Gunwi, Uiseong, Yeongju, Cheongsong, and Yeongcheon in Gyeongbuk province (Table 1). In addition to these areas, four orchards at Geochang, one at Muju and two at Mungkyung, Yecheon and Jangsu, respectively were selected as fixed survey site in 1997 (Table 1). These sites and those selected at the first survey in 1992 were surveyed monthly (Table 1). In 1998, the survey areas were further expanded to other provinces, Chungnam, Chunbuk, Gyeonggi and Gangwon, where the survey was conducted once in 3 months (Table 1). The disease incidence was examined qualitatively, and the appearance frequency of each disease was graded into 3 classes (Table 3).

In the survey from 1992 to 2000, twenty-eight diseases including 23 fungal, two bacterial diseases, one viral and one viroidal disease were identified (Table 2). The noticeable phenomenon in the pattern of diseases occurrence during the survey period was the disappearance of scab since 1997, and breaking out of Marssonina blotch in 1993 followed by its stabilization as an economically important disease thereafter. Apple scab had initially been introduced from the United States with apple seedlings in early 1970s (Kim et al., 1974), no further reports on the occurrence from 1975. However, it was reappeared in 1990 at various localities, mostly in high elevation area, and was gradually spread out to wider areas until 1995 (Ahn et al., 1993). Incidence and localities where the disease occurred were drastically decreased from 1997, and eventually disappeared almost completely thereafter (Uhm, 2000).

Among the 17 fruit diseases found in this survey, white rot and bitter rot were major diseases of apple, causing economically important losses in apple-producing areas in Korea. White rot was most predominant disease that can be seen in almost all of orchard on Fuji cultivar (Table 3), and

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Table 1. Details of survey sites for apple diseases

Province	Localities		Year survey initiated	No. fields surveyed	Survey interval	Cultivars ^a
		Gun				
Gyungbuk		Andong, Gunwi	1992	25~31	monthly	Fuji, Tsugaru, Hongro, Chukwang, Gamhong, Hwahong, Kogetsu, Jonathan, Miki-life
		Uiseong, Yeongju,	1992			
		Cheongsong,	1992			
		Yeongcheon	1992			
		Munhyung	1997	2	monthly	Fuji, Tsugaru, Hongro, Kogetsu
	Yecheon	1997	2	monthly	Fuji, Tsugaru, Hongro, Chukwang, Gamhong	
Gyungnam		Geochang	1997	4	monthly	Fuji, Tsugaru, Hongro, Gamhong,
Junbuk		Muju	1997	1	monthly	Fuji, Tsugaru
		Jangsu	1997	2	monthly	Fuji, Tsugaru, Hongro, Kogetsu
Chungbuk		Chungju	1998	3	3 months	Fuji, Tsugaru, Hongro
Chungnam		Yesan	1998	5	3 months	Fuji, Tsugaru, Hongro
Gyunggi		Paju	1998	1	3 months	Fuji, Tsugaru, Hongro
Gangwon		Hongcheon	1998	1	3 months	Fuji, Tsugaru, Hongro

^aFuji (Ralls Janet × Delicious); Tsugaru (Golden Delicious × Jonathan); Hongro (Spur EarliBlase × Spur Golden Delicious); Chukwang (Fuji × Moris Delicious); Gamhong (Spur EarliBlase × Spur Golden Delicious); Hwahong (Fuji × Sekaiichi); Kogetsu (Golden Delicious × Jonathan); Jonathan (Esopus Spitzenberg × unknown); Miki-life (Shenshu × Tsugaru).

caused severe damage in many orchards. The incidence quite varied in the state of orchard management and even by the year. In 1998, as an extreme case, the disease was so severely occurred that many farmers even gave up the harvest. As the Fuji cultivar that is predominant more than 70% among apples grown in Korea was highly susceptible to this disease, the branches and even small twigs of the cultivar were usually affected to form warts that eventually lead to rough bark. The warts were also found on the stems of some early- or mid-season varieties such as Tsugaru and Hongro, but fruit rot were very rare on the former.

Bitter rot was also found in many cultivars among which Hongro, and Chugwang were highly susceptible. Fuji cultivar known to be moderately resistant to this disease (Ijima, 1999) was also attacked, but at much lower incidence than white rot. A highly significant varietal difference in the susceptibility to this disease was reported (Ijima, 1999; Lee et al., 1993). Two fungi, *Collectotrichum gloeosporioides* and *C. acutatum* were isolated from diseased fruit, and the isolation ratio of the two fungi quite varied in orchard (Kim, 2003).

Sooty blotch and fly spec were also found in almost all of the localities surveyed and sometimes caused serious damages, especially on bagged apple to which the fungicides were inadequately sprayed before bagging.

Moldy core and core rot of apple, caused by several fungi including *Alternaria* sp., *Fusarium* sp., and *Cladosporium* spp. and others occurred widely in major growing areas with great variability in incidence by the year and by the orchards. Especially, cv. Chugwang, a mid-season variety was highly susceptible to this disease as the calyx of the fruit is opened.

Several minor disease that seldom be found were observed. Brown rot caused by *Monilinia fructigena* showing soft decay of fruit with tufts of gray mold on the surface of lesion was found in only one site at Gunwi-gun in 1998 (Table 3). Blossom blight (*M. mali*), which is characterized with transparent liquid exuding from the fruit (Fig. 1-A), was observed for the first time in one orchard at Andong-gun in late May, 1997, but has been occasionally observed in Chungbuk and Gyeonggi province (Table 3). Pink rot caused by *Cephalothecium roseum* was found on the bagged fruits with a small number at Gunwi-gun in late October, 1999, (Fig. 1-B), but was never observed thereafter even at the same orchard (Table 3). Brooks fruit spot caused by *Mycosphaerella pomi* was once found on cv. Tsugaru with considerably high incidence at Yecheon areas in 1998, and as well as the pink rot, it was never observed until 2000 even at the same orchard (Table 3).

Nine foliar diseases were found in this survey, among which Marssonina blotch, caused by *Diplocarpon mali* was most serious disease causing considerable damage every year. At the beginning of this survey in 1992, it was widely distributed but caused little damage. However, in 1993, due to the cold weather during the summer, a severe epidemic was broken out for the first time, and was repeated every year ever since. In recent years, it becomes the most important disease in apple growing in Korea. The disease usually occurs on leaves, but rarely on fruit and even on stems (Takahashi and Sawamura, 1991; Yukita, 2003). The fruit infection in Korea was detected for the first time in 1999 at only one site in Gunwi-gun, showing small, black acervuli on the fruit surface (Fig. 1-C). Blue mold caused by *Penicillium expansum*, as being a post-harvest disease,

Table 2. Apple diseases detected in Korea during the survey period from 1992 to 2000 and cultivars (rootstocks) on which the diseases were found

Disease	Causal agent	Year detected	Cultivars & rootstocks ^a
Valse Canker	<i>Valsa ceratosperma</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Blossom blight	<i>Monilinia mali</i>	1997, 2000	Fj, Tg
Powdery mildew	<i>Podosphaeria leucotricha</i>	every year	Fj, Jn
Alternaria leaf spot	<i>Alternaria mali</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Rust	<i>Gymnosporangium yamadae</i>	every year	Fj, Tg, Hr, Ck, Kg
Scab	<i>Venturia inaequalis</i>	1992-1997	Fj, Tg, Kg
Marssonias blotch	<i>Diplocarpon mali</i>	every year	Fj, Tg, Hr, Ck, Gh, Hh
Sooty blotch	<i>Gloeodes pomigena</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Fly speck	<i>Zygothiala jamaicensis</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Moldy Core and Core rot	<i>Alternaria</i> sp.	every year	Fj, Tg, Kg
	<i>Fusarium</i> sp.	every year	Fj, Tg
	<i>Cladosporium</i> spp.	every year	Fj, Tg
Brooks fruit spot	<i>Mycosphaerella pomi</i>	1998	Tg
Silver leaf	<i>Stereum purpureum</i>	every year	Fj
Phomopsis canker	<i>Phomopsis mali</i>	every year	Fj
Gray mold	<i>Botrytis cinerea</i>	every year	Fj
Phytophthora rot	<i>Phytophthora cactorum</i>	every year	Fj, Tg, Hr
	<i>Phytophthora camvibora</i>	every year	Fj
Leaf spot	<i>Leptosphaeria</i> sp.	since 1998	Fj
White root rot	<i>Rosellinia necatrix</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Violet root rot	<i>Helicobasidium mompa</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Bitter rot	<i>Glomerella cingulata</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
White rot	<i>Botryosphaeria dothidea</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Brown rot	<i>Monilinia fructigena</i>	1998	Fj
Pink rot	<i>Cephalothecium roseum</i>	1999-2001	Fj
Blue mold	<i>Penicillium expansum</i>	every year	Fj
Mosaic	<i>Apple mosaic virus</i>	every year	Fj, Tg, Hr, Ck, Kg, Jn
Viroid	<i>Apple scar skin viroid</i>	since 1998	Fj, Tg, Hr, Ck, Gh, Hh, Kg, Jn, Mk
Southern blight	<i>Athelia rolfsii</i>	since 1998	all the rootstocks
Crown gall	<i>Agrobacterium tumefaciens</i>	1996, 2000	M.9, M.26
Hairy root	<i>Agrobacterium rhizogenes</i>	1995	MM.106

^aFj, Fuji; Tg, Tsugaru; Hr, Hongro; Ck, Chukwang Gh, Gamhong; Hh, Hwahong; Kg, Kogetsu; Jn, Jonathan; Mk, Miki-life

frequently found in almost all of the storage.

Alternaria blotch caused by *Alternaria mali* was also observed in almost all of orchard in every year (Table 3), but seldom caused defoliation on Fuji cultivar unlike the implication of its Korean name. However, it has been known to cause considerable damage even on Fuji cultivar in Gyeongju area ranging to southern part of Yeongcheon where this disease was initially found (Uhm, 2005). Recently, severe epidemics on young tree of Fuji cultivar grafted on M.9 root stock, usually less than 5 years old, were frequently found, but the cause of it are still unknown. A completely different type of Alternaria blotch of which lesions are much larger than that of ordinary type occasionally occurred in northern part of Gyeongbuk province on several cultivars including cv. Fuji (Fig. 1-D). This type of

blotch was also reported in Japan (Sakagami and Kodou, 1995).

Powdery mildew was found at several sites in Gyeongbuk, but very rare (Table 3). The disease was mainly found on cv. Jonathan which is known to be susceptible to this disease, but not all of orchard where the cultivar is grown. Rust caused by *Gymnosporangium yamadae* was occurred almost of the orchard tested (Table 3). However, it seldom caused economical damage, since it was effectively controlled by the EBI fungicides sprayed at petal fall. Gray mold caused by *Botrytis cinerea* and leaf spot caused by *Leptosphaeria* sp. and silver leaf caused by *Stereum purpureum* were the minor disease which was rarely observed at several sites (Table 3).

Several canker and wood rot diseases were found, among



Fig. 1. Symptoms of apple diseases. (A) Blossom blight caused by *Monilinia mali*, (B) Pink rot caused by *Cephalothecium roseum*, (C) Symptom on apple fruit caused by *Diplocarpon mali*, (D) Fluidal type of *Alternaria* leaf spot caused by *Alternaria mali*.

which *Valsa* canker caused by *Valsa ceratosperma* was commonly found in almost all of orchards except of young M.9 rootstock trees. The cankers on trunks and branches were drastically reduced by the application of neosozin solution since 1989 (Uhm and Sohn, 1995), but still occurred with considerably high incidence on twigs of old trees. Phomopsis canker caused by *Diaporthe pernicioso* were also found at most of sites in Gyeongbuk and Gyeongnam Province (Table 3), and sometimes occurred on fruit at storage. The fungus causing white rot on fruit, *Botryosphaeria dothidea*, also caused canker on trunks and branches of several cultivars, among which cv. Hongro was most susceptible and sometimes led to tree death. Southern blight (*Corticium rolfsii*) was frequently observed at commercial nursery stool bed in Gyeongbuk (Table 3). In one case, the blight was so severe that the stool bed was even completely closed in Gyeongbuk province.

Phytophthora root rot caused by *Phytophthora cactorum* and *P. cambivora* (Jee et al., 1997a; Jee et al., 1997b), was also found in many places (Table 3), mainly on MM.106 rootstock at the orchards where herbicides has been used

for control of weeds. The fruit rot caused by the same fungi was also frequently observed in almost all of the localities, but incidence of which was not serious. However, when the apple tree was submerged under floodwaters almost all of the fruit became rot by this disease. The *Phytophthora* root rot once seriously occurred in late 1990s in Gyeongbuk area was overcome by adoption of sod-culture.

White root rot caused by *Rosellinia necatrix* and violet root rot caused by *Helicobasidium mompa* was also found at almost all of localities but not in all orchards (Table 3). Crown gall caused by *Agrobacterium tumefaciens* was observed at each one nursery stool bed in Gyeongbuk and Chungbuk, and hairy root caused by *Agrobacterium rhizogenes* was found at only one site in Gyeongbuk Province (Table 3).

In 1998, a viroidal disease was found on cv. Miki-life at one orchard in Uiseong-gun, and its cause was identified as apple scar skin viroid (Lee et al., 2001). Soon after, the disease was found in many places on various cultivars. Latter, it was elucidated that the disease was originated from several commercial nursery. As the diseased trees

Table 3. Description, their frequency and localities of apple diseases in Korea

Diseases	Causal agent	plant part attacked				Degree of disease incidence ^a	Areas ^b
		Stem	Leaf	Fruit	Root & rootstocks		
Valse Canker	<i>Valsa ceratosperma</i>	○			○	+++	all the country
Blossom blight	<i>Monilinia mali</i>		○	○		+	Gb, Cb, Gg
Powdery mildew	<i>Podosphaeria leucotricha</i>		○	○		+	Gb
Alternaria leaf spot	<i>Alternaria mali</i>	○	○	○		+++	all the country
Rust	<i>Gymnosporangium yamadai</i>		○	○		+++	all the country
Scab	<i>Venturia inaequalis</i>		○	○		+	Gb, Gn
Marssonina blotch	<i>Diplocarpon mali</i>		○	○		+++	all the country
Sooty blotch	<i>Gloeodes pomigena</i>	○		○		+++	all the country
Fly speck	<i>Zygophiala jamaicensis</i>			○		+++	all the country
Moldy Core and Core rot	<i>Alternaria</i> sp.			○		++	all the country
	<i>Fusarium</i> sp.			○		+	Gb, Cb, Gg
	<i>Cladosporium</i> spp.			○		++	Gb
Brooks fruit spot	<i>Mycosphaerella pomi</i>			○		++	Gb
Silver leaf	<i>Stereum purpureum</i>		○	○		+	Gb
Phomopsis canker	<i>Phomopsis mali</i>	○		○		++	Gb, Gn
Gray mold	<i>Botrytis cinerea</i>		○	○		+	all the country
Phytophthora rot	<i>Phytophthora cactorum</i>	○	○	○	○	+	all the country
	<i>Phytophthora cambovora</i>				○	+	Gb, Gn
Leaf spot	<i>Leptosphaeria</i> sp.		○			+	Gb
White root rot	<i>Rosellinia necatrix</i>				○	++	Gb, Gn, Jb, Jn, Cb, Cn
Violet root rot	<i>Helicobasidium mompa</i>				○	++	Gb, Gn, Jb, Jn, Cb, Cn
Southern blight	<i>Athelia rolfsii</i>	○			○	+	Gb, Cb
Bitter rot	<i>Glomerella cingulata</i>	○		○		+++	all the country
White rot	<i>Botryosphaeria dothidea</i>	○		○		+++	all the country
Brown rot	<i>Monilinia fructigena</i>			○		+	Gb, Gw
Pink rot	<i>Cephalothecium roseum</i>			○		+	Gb
Blue mold	<i>Penicillium expansum</i>			○		+++	all the country
Crown gall	<i>Agrobacterium tumefaciens</i>				○	+	Gb, Cb
Hairy root	<i>Agrobacterium rhizogenes</i>				○	+	Gb
Mosaic	<i>Apple mosaic virus</i>		○			++	Gb, Jn, Cb, Cn
Viroid	<i>Apple scar skin viroid</i>			○		+	Gb, Gn, Jb, Jn, Cb, Cn

^a+, rare; ++, frequent; +++, ubiquitous.

^bGb, Gyeongbuk; Gn, Gyeongnam; Jb, Jeonbuk; Jn, Jeonnam; Cb, Chungbuk; Cn, Chungnam; Gg, Gyeonggi; Gw, Gangwon province

were instantly eliminated from the most of the orchard by the farmers, the viroidal disease is no longer problematic at present. Although 4 viral diseases were described in Korea (The Korean Society of Plant Pathology, 2004), only one viral disease, *Apple mosaic virus* (ApMV), was found occasionally in this survey at all localities (Table 3).

Among the 28 parasitic diseases found in this survey, moldy core was turned out to be non-described disease in Korea (The Korean Society of Plant Protection, 1972, 1986; The Korean Society of Plant Pathology, 1998, 2004). From the fact that moldy core is one of the prevailing disease which can be seen at any orchard, and it sometimes cause considerable damage, the exclusion of this disease

from the list was thought to be caused by a mistake. Therefore, moldy core should be listed in "List of Plant Diseases in Korea".

In the list of plant diseases in Korea (The Korean Society of Plant Pathology, 2004) 41 parasitic apple diseases including one nematodal disease were described, among which 12 diseases were not found in this survey. Consequently, these diseases would be found in future as the survey sites are expanded. However, the five diseases, fire blight (*Erwinia amylovora*), black rot (*Botryosphaeria obtusa*), scab (*Cladosporium carpophilum*), Monochaetia twig blight (*Monochaetia* sp.), and brown leaf spot (*Hendersonia mali*) were once described long ago but no

further reports on the disease occurrence are available. As those diseases were not found in this survey as well, actual occurrences were thought to be questionable. However, some of the minor diseases such as brown rot observed in this survey were so rare that they seldom been observed, thus more effort should be paid to determine their occurrence in Korea. This survey is still going on, and the results will be published at every 5-year interval.

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