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Interception of *Venturia inaequalis*, a pathogen of quarantine significance in apple shipments imported into India

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ABSTRACT: This paper reports the interception of *Venturia inaequalis,* a pathogen of quarantine significance in apple consignments imported to India. During 2018–2020, apple shipments from eighteen countries representing six continents were imported through Chennai port. Shipments from seven countries representing five continents were intercepted with quarantine fungal pathogens *Venturia inaequalis* and *Monilinia fructicola*. The intercepted shipments were issued Deportation Orders as per the provisions of Plant Quarantine (Regulation of Import into India) Order, 2003. The non-compliances were notified to the trading partners on each interception as per the IPPC guidelines.

Keywords: Apple scab, DIP Act, domestic quarantine, IPPC, invasive Pest, PQ Order, *Venturia inaequalis*

INTRODUCTION

In India, apple is primarily cultivated in the hilly areas of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand states and to limited extent in the northeastern states of Arunachal Pradesh and Nagaland. In many of these states, apple is the source of livelihood and economic security of small and medium farmers besides a rich source of nutritional security. Apple has been introduced to hilly areas of southern states like Kerala, Tamil Nadu, and Karnataka. During 2020, India produced 2.3 million tons of apples domestically as against annual consumption is 2.35 million tons. India is importing 2,15,000 tons of apples annually to meet the off-season demand. United States of America, New Zealand, Italy, Chile, and Turkey are the major exporters of apples to India. China was the major exporter till 2017, prior to banning import of Chinese apples due to repeated interception of mealybug, *Pseudococcus comstocki* and *Fusarium* spp., pests of quarantine significance in India. The main insects of concern to India are Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann); Apple maggot, *Rhagoletis pomonella* Walsh; Queensland fruit fly, *Bactrocera tryoni* (Froggatt); Natal fruit fly, *Ceratitis rosa* Karsch (all Diptera: Tephritidae); Raspberry beetle, *Byturus tomentosus* (De Geer) (Coleoptera: Byturidae), Red plum maggot, *Grapholita funebrana* Treitschke; Oriental fruit moth, *Grapholita molesta* (Busck), Manchurian fruit moth, *Grapholita inopinata* Heinrich (all Lepidoptera: Tortricidae) (PQ Order 2003).

Apples are being imported from different countries with mandatory pre-shipment cold treatment as specified in the Schedule VI of Plant Quarantine (Regulation of Import into India) Order, 2003. The fruits should be treated at or below 0^0 C or 0.55^0 C or 1.1^0 C for 10 or 11 or 12 days, respectively in addition to in-transit refrigeration. The pre-shipment cold treatment is aimed at mitigating the risk associated with exotic insects associated with apples. Often, treatments are not effective as seen in case of apples imported from China. Therefore, strict quarantine inspections are mandatory at the point of entry and all the plant pathogens intercepted should be carefully examined in the laboratory.

MATERIALS AND METHODS

Apples imported through Chennai port are being regularly inspected and released for consumption purpose by the Regional Plant Quarantine Station, Chennai as per the provisions of the Plant Quarantine (Regulation of Import into India) Order, 2003 issued under Destructive Inspects Pests Act 1914 (DIP Act 1914). During 2018–2020, 5332 apples shipments were imported from 18 countries were inspected. The deformed fruits showing symptoms of corky tissue, spots, fruits having a foul smell, wounds, discoloration, etc. were segregated and moved with all precautions to the laboratory at Regional Plant Quarantine Station, Chennai for further examination. Infected parts of the fruits were selected, surface sterilization and sectioning on a glass slide and observed under a compound microscope (Olympus, CX43). Observations on mycelial characteristics, fruiting bodies, sexual and asexual spores were recorded. Further, infected fruits were kept for 48 hours in a moist chamber for sporulation. Sections were stained after 48 hours using Lactophenol cotton blue reagent for the identification.

Table 1. Shipments imported and intercepted with exotic fungal pathogens during 2018–2020

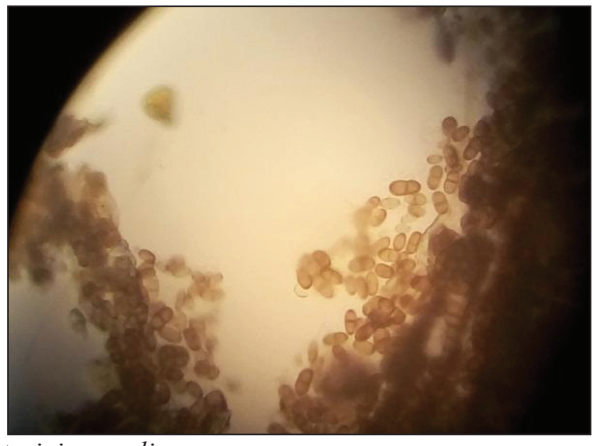
Country	Import		Interception	
	# Shipments	Quantity (MT)	# Shipments	Quantity (MT)
Africa				
Egypt	2	83	Nil	Nil
South Africa	24	582	Nil	Nil
Asia				
Iran	47	2,009	Nil	Nil
Japan*	1	0.03	1	0.03
Turkey	394	14,249	6	179
European Union				
Belgium	35	679	1	18
France	140	3,193	Nil	Nil
Germany	4	85	Nil	Nil
Greece	8	181	4	161
Italy	1,161	37,120	3	63
Netherlands	49	990	Nil	Nil
Poland	417	14,205	Nil	Nil
Spain	3	106	Nil	Nil
Ukraine	1	22	Nil	Nil
North America				
USA	1,385	57,943	Nil	Nil
Oceana				
Australia	11	292	Nil	Nil
New Zealand	574	18,575	1	21
South America				
Brazil	108	2,815	Nil	Nil
Chile	968	44,199	3	63
	5,332	**1,97,328.03**	**19**	**505.03**

Fungal morphology of the suspected sample was observed microscopically using Olympus (CX43) compound microscope. For the purpose, a small portion of the mycelium was mounted on a glass slide, stained using a lactophenol cotton blue and observed under the microscope (Gaddeyya *et al.,* 2012).

RESULTS

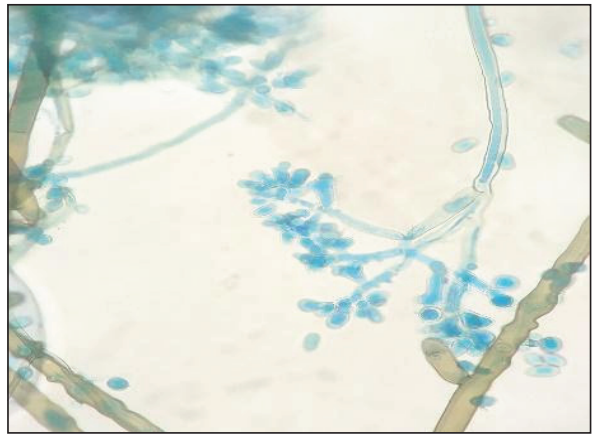
During 2018–2020, a total of 5,332 shipments amounting to 1,97,328.03 MT of apples were exported by 18 countries representing six continents to India. Countries namely USA (57,943 MT), Chile (44,199 MT), Italy (37,120 MT), New Zealand (18,575 MT), Turkey (14,249 MT) and Poland (14,205 MT) were the major exporters constituting nearly 95% of total imports into India,followed by France (3,193 MT), Brazil (2,815 MT), Iran (2,009 MT), Netherlands (990 MT), Belgium (679 MT), South Africa (582 MT), Australia (292 MT), Greece (181 MT), Spain (106 MT), Germany (85 MT), Egypt (83 MT) and Ukraine (22 MT) (Table 1).

Apples from Turkey (179 MT), Greece (161 MT), Chile (63 MT), Italy (63 MT), New Zealand (21 MT), Belgium (18 MT) and Japan (300 kg) were observed to be infected with *V.inaequalis.* Fruits imported from



Apple scab, *Venturiaina equlis*

Brown rot, *Monilinia fructicola*



Botrytis cinerea

Fig. 1. Fungal pathogens intercepted in imported apple shipments

Greece and Italy were additionally infected with *M.fructicola,* whereas fruit of Australia, Brazil, South Africa, Egypt, Poland, France, Germany, Spain, Netherlands, Iran, and USA were free from infection. Of the total infected shipments (19 No.), per cent infected shipments were highest for Turkey (32%) followed by Greece (21%), Chile and Italy (16% each), Belgium, Japan and New Zealand (5% each).

Further, fruits were observed associated with dead insects representing Coccidae, Lepidoptera and saphrophytic Diptera and spiders were observed too on imported fruits.

Table 2. List of pests with details under domestic quarantine in India

Sl. No.	Pest/Disease	Host Plant	From	To
1	Fluted Scale (*Icerya purchasi*)	Citrus and woody plants	Mysore, Chennai (T N) & Kerala	Any other part of India
2	San Jose Scale (*Aspidiotus perniciosus*)	Apple and Pome fruits	Punjab, UP, Madras (TN), WB, Assam, Orissa, HP, Jammu & Kashmir	Any other part of India
3	Banana Bunchy top (virus)	Banana planting material	Assam, Kerala, Orissa, T N, & West Bengal	Any other State & UT
4	Banana mosaic (virus)	Banana plants& plant material	Maharashtra & Gujarat	Any other State &UT
5	Potato Wart (*Synchytrium endobioticum*)	Potato	Darjeeling (WB)	Any other State or place in India
6	Apple Scab (*Venturi ainaequalis*)	Apple planting material	Jammu & Kashmir, Himachal Pradesh	Any other State
7	Codling Moth (*Carpocapsa pomonella*)	Apple & walnut plants including fruits	Ladakh District (J&K)	Any other area in J&K
8	Potato Cyst Nematodes (*Globodera rostochiensis &G. pallida*)	Potato	Tamil Nadu, H.P., Uttarakhand, J&K	Any other State & UT
9	Coffee Berry Borer (*Hypothenemus hampei*)	Coffee seeds/plants/ powder	Nilagiri Dt (T.N), Kodagu Dt (Karnataka) &Wayanad Dt (Kerala)	Any other parts of the Indian Union

(Sushil *et al.,* 2021)

DISCUSSION

Apple scab, *Venturia inaequalis* and Brown rot, *Monilinia fructicola*, the pathogens of quarantine significance to India were intercepted on apple shipments imported from seven countries representing five continents including Asia. Scab is most devastating disease throughout apple growing areas of the world. In India, it was first reported in 1935 in the Kashmir Valley, causing havoc in apple cultivation in Jammu and Kashmir and Himachal Pradesh. The disease affects the fruit quality by inducing blemishes and the infected fruits fail to ripe. Yield loss could be up to 70% to complete loss depending on the virulence of the pathogen and management practices followed. The studies conducted by different workers shows the genetic variability among the isolates of *V. inaequalis* infecting different cultivars, locations, countries and continents. Further, the virulence of the pathogen is also known to vary with these isolates (Jha, 2009 and Xu, 2008).

In India, Apple scab pathogen is a notified Domestic Quarantine pest since 1979. The Government of India notification restrict the movement of planting materials from Jammu and Kashmir to other apple growing areas to prevent the spread of disease to newer areas (Table 2). Further, *V. inaequalis*hasa number of alternate hosts of rosaceous ornamentals, such as crabapples, *Malus*s pp., loquat *Eriobotrya japonica* and hawthorn *Crataegus* sp. that are spread throughout India (Sushil *et al*., 2021).

Monilinia fructicola also called American brown rot of stone fruit, brown rot of apple, brown rot of cherry, twig canker of stone fruit, etc. causes blossom blight, twig blight, twig canker and fruit rot. In

India, the pathogen is limited to Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh (CABI, 2021). In addition, *Alternaria* sp. *Cladosporium cladosporioides, Colletotrichum* sp. *Diplodia* sp. *Drechslera* sp. *Stemphylium* sp. *Ulocladium* sp. intercepted in the imported shipments are the non-quarantine funguses. However, these fungi have potential to cause fruit loss in the storage, therefore are economically important from the consumer point of view.

Interception of dead insects representing Coccidae, Lepidoptera, saphrophytic Diptera, and spiders demonstrates potential, non-target, accidental introductions associated with apple import. However, dead insects demonstrate the efficacy and necessity of pre-shipment cold treatment and in transit refrigeration. This could be one of the reasons for non-interception of potential quarantine pests such as tephritid fruit flies and other external feeders.

Intercepted fungal pathogens such as *V. inaequalis* and *M. fructicola* have potential to cause enormous economic damage on the native flora both in the wild and cultivated fields, if accidentally imported. Further, intercepted pests are storage pests on apples. Therefore, imported shipments were issued for Deportation Orders as per the provisions of PQ Order and the non-compliances were notified to the trading partners on each interception as per the IPPC guidelines.

In a vast country like ours with varied agro-climatic regions, crops, and high biodiversity invasive can upset the apple cart literally. These interceptions reinforce scientific opinion that investments in diagnostics, identification, vigilance is vital for security of agrobiodiversity, natural biodiversity, and farmers welfare.

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