Seed-borne Pathogens Intercepted in Germplasm Introduced in India During 2005-06

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Quarantine processing of 1,48,917 samples of seeds and other planting material of various agri-horticultural crops imported during 2005-2006 resulted in the interception of 34 fungi and one bacterium. These interceptions included pathogens of quarantine significance, *viz*., *Peronospora manshurica*, a fungus not known to occur in India; *Tilletia foetida* and *Botrytis cinerea* with a limited geographical distribution in the country; *Drechslera maydis* and *Phoma lingam* which are known to possess physiological races; *Colletotrichum dematium*, *Drechslera sorokiniana*, *Fusarium moniliforme*, *F. solani* and *Macrophomina phaseolina*, with wide host range and other pathogens reported to cause significant economic losses e.g. *Alternaria brassicicola*, *A. sesame*, *A. padwickii*, *A. radicina*, *Verticillium albo-atrum* and *Xanthomonas campestris* pv. *campestris*, etc. Economic significance of pathogens intercepted is discussed and the need to conduct a thorough and critical seed health testing during quarantine processing for safer introduction of planting material is emphasized.

Key Words: Germplasm, Quarantine, Interception, Pathogens

Introduction

International exchange of germplasm has played an important role in the crop improvement programme world over. Since a large number of pathogens are known to be seed-borne/ transmitted, there is always an inadvertent risk of introducing new pathogens or their more virulent strains along with introduced planting material. National Bureau of Plant Genetic Resources (NBPGR), New Delhi is the nodal agency for exchange (import/export) and undertaking quarantine clearance of germplasm meant for research use by public as well as private sector. Every year > 60,000 samples of various agri-horticultural crops and their wild relatives are processed for quarantine clearance. During quarantine processing a large number of pathogens have been intercepted (Khetarpal *et al*., 2001) including pathogens which are not reported from India such as *Peronospora manshurica* (Naum.) Syd. (Agarwal *et al*., 2006a); *Uromyces betae* Kickx (Agarwal *et al*., 2006b); *Fusarium nivale* (Fr.) Ces. (Dev *et al*., 1989); and a new fungus, *Drechslera pluriseptata* sp. nov. (Khetarpal *et al*., 1984). In this paper, 35 pathogens intercepted in germplasm and trial material introduced during 2005-2006 are reported and economic significance of major ones is discussed.

Materials and Methods

During 2005-06, a total of 348 consignments comprising of 1,48,917 samples (43,017 germplasm and 1,05,900 samples of international trial material) of various agri-horticultural crops and their wild relatives from 47 countries were received for quarantine processing. It comprised of 314 consignments (1,47,620 samples) of true seeds and 34 consignments (1,297 samples) of vegetative propagules such as rooted plants, bud wood cuttings, tubers and *in vitro* plantlets of > 50 crop species. The highest number of consignments were received from USA (87) followed by the Philippines (51), Mexico (48), Taiwan (31), Australia (18), Thailand (14) and Syria (7) and remaining 92 from the other 40 countries. Wheat with 62,743 samples (61 consignments) constituted the largest import followed by rice with 49,867 samples (59 consignments) and maize with 11,133 samples (51 consignments).

All the samples were tested as per standard seed testing procedures (ISTA, 1968). Samples were first subjected to dry examination under stereo-binocular microscope for bacterial/fungal symptoms like discoloration, pigmented, deformed and abnormal seeds, presence of infected seeds or fungal fructification, mycelium or spores on the surface of seeds or planting material. Seed samples coated with microbial cultures and/or suspected to carry traces of externally-borne spores were subjected to washing test by mechanical stirring seeds in small quantity of distilled water. Apparently unhealthy looking seeds and small portions from planting material showing pigmentation or abnormal growth were

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subjected to incubation test by placing them on moist blotter discs in plastic petri plates. Number of seeds tested varied from 10- 400 depending on the size of the sample being tested. The plates were incubated for 7 days at 20 ± 1°C under alternate cycles of light and darkness and were examined on eighth day under stereo-binocular microscope for the associated pathogens. The pathogens were identified on the basis of bacterial/fungal growth and colony characters. Wherever required, slides were prepared and examined for spore/conidial characters for identification of pathogen up to species level. Infected samples were decontaminated/disinfected by suitable physical or chemical treatment.

Eight thousand nine hundred and forty four (8,944) chemically treated samples of international trials of wheat (6,391), barley (2,240) and triticale (313) were grown in post-entry quarantine nursery (PEQN), NBPGR, New Delhi, for detection of seed-borne diseases.

Samples of various crops found infected/ contaminated and pathogens detected during dry examination, incubation test and PEQN along with their source/country, total number of samples received, samples found infected and per cent samples infected are listed in Table 1.

Results and Discussion

During visual examination under stereo-binocular microscope, downy mildew fungus of soybean, *P. manshurica* was detected as a crust of oospores on seed surface. Examination of decant from washing test also revealed oospores of the fungus. *P. manshurica* was intercepted in nine samples from Taiwan (6) and USA (3). As per the Plant Quarantine (Regulation of Import into India) Order (2003), for any import of soybean seeds for sowing purposes an additional declaration is required in the Phytosanitary Certificate issued by the exporting country, certifying the consignment to be free from this fungus. *P. manshurica* is not yet reported from India, however, it has been repeatedly intercepted on soybean seeds from several countries including Malaysia and Indonesia where the disease is not officially recorded (Agarwal *et al.*, 2006a). Oospores are reported to retain viability up to eight years in soil and a large number of physiological races are reported in *P. manshurica* (Marcinkowska, 1991; Li *et al.*, 1992; Hartman *et al.*, 1999). Total yield losses due to soybean downy mildew in Argentina, Canada, China, Italy and USA were estimated to be 3,87,900 metric tonns (Wrather *et al.*, 1997). *P. manshurica* was observed in France in 1974 (Signoret *et al.*, 1975) indicating the possibility of its spread into new areas. In view of this, fungus being a quarantine pest for India, its interception is of high quarantine significance. All the infected samples were rejected and incinerated.

Tilletia foetida (Wallr.) Liro, the causal agent of common bunt or hill bunt of wheat with smooth walled uredospores was intercepted in one sample of *Triticum* sp. from USA. In India, the disease is restricted only to Delhi, Himachal Pradesh, Jammu and Kashmir, and Punjab. In the past, *T. foetida* was frequently intercepted in wheat imported from 15 countries (Dev *et al.*, 2005). Common bunt is an important disease in many wheat growing areas of the world. The ustilospores can survive for several years on contaminated seed and in the soil and the unfavorable odour affects the market value of wheat. More than 50% crop losses were reported in the crop raised from untreated seeds in Turkey (CABI, 2006) and in Australia average potential loss due to bunt was estimated up to 361 million Australian dollars (Brennan and Murray, 1988). Teliospores of *Puccinia helianthi* the causal organism of rust were detected in 25 samples of sunflower from USA (9), Egypt (5) and France (11) in washing test.

During blotter test, *Alternaria brassicae* (Berk) Sacc., the causal fungus of grey leaf spot in brassicas was intercepted in one sample out of the two samples of *Crambe abyssinica* received from UK. *A. brassicae* causes pre- and post-emergence damping off of seedlings resulting in yield losses. Yield losses up to 70 per cent were reported from various parts of the world (CABI, 2006). *Alternaria brassicicola* (schw.) Wilts., the causal agent of black spot, was intercepted in 44 samples of *Brassica* spp. from Australia (16), Canada (25), China (1) and the Netherlands (2) and one sample each of *C. abyssinia* from UK, *Capsicum* sp. from Russia and *Citrullus lanatus* from China. Though *A. brassicicola* has a wide host range (CABI, 2006) and is known to be seed-borne in 10 crops (Richardson, 1990), it is detected on seeds of *Capsicum* and *C. lanatus* for the first time and this is the first report of the fungus being seed-borne on these two crops. During last 25 years, this fungus was repeatedly intercepted on species of *Brassica* and *Allium* (Agarwal *et al.*, 2004). Black spot is regarded as a major disease in brassicas in the Netherlands and other European countries. Infected seeds recorded reduction in germination and seedling vigor, and yield losses of up to 70 per cent have been reported (CABI, 2006). *Alternaria*

Table 1. Seed-borne pathogens intercepted in germplasm introduced in India during 2005-06

Fungi/bacterium intercepted	Crop	Country/ Source	No. of samples	
			Processed	Found infected
Alternaria brassicae[3]	*Crambe abyssinica*	UK	2	1
A. brassicicola[3]	*Brassica juncea*	Australia	10	7
		Canada	400	25
	B. napus	Australia	21	9
	B. oleracea	China	5	1
		Netherlands	392	2
	Capsicum sp.	Russia	9	1
	Citrullus lanatus	China	26	1
	C. abyssinica	UK	2	1
A. lini[3]	*Linum* spp.	Russia	4	2
A. padwickii[3]	*Oryza sativa*	Philippines	49,701	122
A. radicina[3]	*Daucus carota*	China	3	3
	Capsicum spp.	Taiwan	295	1
Botrytis cinerea[3]	*B. juncea*	Germany	8	1
		Canada	400	1
	Carthamus tinctorious	Germany	18	2
	Helianthus annuus	France	350	3
	Hordeum vulgare	Sweden	20	1
Cephalosporium sp[3]	*Beta vulgaris*	USA	12	2
	Capsicum spp.	Taiwan	295	1
	Lycopersicon esculentum	Taiwan	218	1
	O. sativa	Philippines	49,701	3
	Sorghum bicolor	USA	36	3
	Vigna radiata	Taiwan	36	1
	Zea mays	Thailand	1,927	7
Ceratocystis sp.[3]	*C. abyssinica*	UK	2	1
Colletotrichum dematium[3]	*Cicer arietinum*	Syria	3,624	1
	C. abyssinica	UK	2	1
	Glycine max	Taiwan	278	5
		USA	5	1
	Gossypium sp.	USA	1,903	1
	H. annuus	USA	32	5
	L. esculentum	Taiwan	218	2
Curvularia lunata[3]	*O. sativa*	Philippines	49,701	69
	S. bicolor	USA	36	1
Drechslera avenae[3]	*H. vulgare*	Australia	129	1
D. cynodontis[3]	*Capsicum* spp.	Taiwan	295	1
D. maydis[3]	*Z. mays*	Thailand	1,927	4
		Philippines	125	1
D. oryzae[3]	*O. sativa*	Bangladesh	3	1
		Philippines	49,701	15
D. sorokiniana[3]	*B. juncea*	Canada	400	1
	Capsicum sp.	China	34	1
	L. esculentum	Taiwan	218	1
	Poa pratensis	USA	27	1
	Triticum spp.	Belgium	5	1
		USA	1,860	16
		Mexico	64,528	4
		Nepal	5,220	9
D. sorghicola[3]	*Z. mays*	Philippines	125	1
Fusarium culmorum[3]	*H. vulgare*	Australia	129	1
F. dimerum[3]	*O. sativa*	Philippines	49,701	18
F. equiseti[3]	*Capsicum* spp.	Taiwan	295	1
	H. annuus	France	350	1
		USA	32	1
F. moniliforme[3]	*Beta vulgaris*	France	8	1
		USA	12	3
	Capsicum spp.	China	34	1
		Taiwan	295	8
	Citrullus lanatus	China	26	1

Contd.

Table 1 Contd.

Fungi/bacterium intercepted	Crop	Country/ Source	No. of samples	
			Processed	Found infected
	C. abyssinica	UK	2	1
	G. max	Taiwan	278	7
	Gossypium spp.	USA	1,903	10
	H. annuus	France	350	3
	H. vulgare	Australia	129	2
		Sweden	20	1
	L. esculentum	Taiwan	218	3
	O. sativa	Philippines	49,701	104
	Perilla frutescens	USA	19	5
	S. bicolor	USA	36	5
	Triticum spp.	USA	1860	12
		Mexico	64,528	2
	V. radiata	Sri Lanka	3	1
		Taiwan	36	4
	Z. mays	Thailand	1,927	41
		USA	459	28
		Philippines	125	1
F. semitectum[1]	*B. vulgaris*	USA	5	3
	Gossypium spp.	USA	1,903	16
	O. sativa	Philippines	49,701	43
	Triticum sp.	Mexico	64,528	1
	Z. mays	Thailand	1,927	2
F. solani[3]	*C. tinctorious*	Germany	18	1
	C. arietinum	Syria	3,624	1
	Gossypium spp.	USA	1,903	1
	L. esculentum	Taiwan	218	1
	O. sativa	Philippines	49,701	2
Macrophomina phaseolina[3]	*G. max*	Taiwan	278	2
		USA	5	2
Nigrospora oryzae[3]	*Triticum* sp.	Belgium	5	1
Peronospora manshurica[1,2]	*G. max*	Taiwan	278	6
		USA	5	3
Phoma lingam[3]	*B. juncea*	Canada	400	3
Phoma sp.[3]	*Capsicum* spp.	Taiwan	295	1
	H. vulgare	Australia	129	1
	O. sativa	Philippines	49,701	90
	P. frutescens	USA	19	1
	P. pratensis	USA	27	1
	V. unguiculata	Columbia	6	1
Puccinia helianthi[2]	*H. annuus*	USA	32	9
		Egypt	.10	5
		France	350	11
Rhizoctonia bataticola[3]	*O. sativa*	Philippines	49,701	8
R. solani[3]	*B. vulgaris*	USA	5	4
	Papaver dubium	Denmark	6	2
Tilletia foetida[1,2]	*Triticum* spp.	USA	1,860	1
Ustilago nuda[4]	*H. vulgare*	Mexico	2,240	5
Ustilago segetum var. *tritici*[4]	*Triticum* spp.	Mexico	6,391	2
Verticillium albo-atrum[3]	*Capsicum* spp.	Taiwan	295	1
	Carica papaya	Cuba	2	1
	H. annuus	France	350	4
	O. sativa	Philippines	49,701	1
	Solanum melongena	Taiwan	22	1
Xanthomonas campestris pv. *campestris*[3]	*B. juncea*	Canada	400	6
		USA	4	1
		Germany	8	2
	B. napus	Germany	42	5

Pathogen detected during: 1-dry examination; 2-washing test; 3–incubation test; 4-PEQN *linicola* Groves and Skolko, the causal organism of seedling blight in flax was intercepted in two out of 4 samples of linseed received from Russia. *A. linicola* is regarded as an important pathogen in most flax growing areas, and can seriously decrease emergence when infected seed is sown (Mercer *et al.*, 1991).

Alternaria padwickii (Ganguly) M.B. Ellis, the causal agent of stack burn disease of rice was intercepted in 122 samples of paddy from the Philippines. Grain discoloration, caused by this fungus alone or in combination with other fungi, can reduce the market value of the crop (Saini, 1985). *Alternaria radicina* Meier, Drechsler & Eddy, the black rot fungus of carrots has a wide host range and known to be seed-borne in 10 crops. The fungus was intercepted in *Daucus carota* from China (3) and *Capsicum annuum* from Taiwan (1). There is no report of *A. radicina* infecting *Capsicum* and hence this is a new host record for the fungus. Besides, the fungus is not reported to occur in Taiwan and the information regarding the origin of the accession found infected is not available i.e. whether originated from Taiwan or collected by AVRDC, Taiwan from other source. The fungus is known to cause considerable damage in the storage resulting in reduction of seed quality and germination. A distinction is made by some authorities between the eastern and western races of the cultivated carrot, where a greater degree of resistance is known to occur in the western race (CABI, 2006).

Botrytis cinerea Pers. Fr, the grey mould fungus was intercepted in *Brassica juncea* from Canada and Germany (one each), *Carthamus tinctorius* from Germany (2), *Helianthus annuus* from France (3) and *Hordeum vulgare* from Sweden (1). Due to the wide host range, *B. cinerea* is considered a constant threat to agricultural crops (CABI, 2006). The fungus is also known to be seed-borne in 56 crops (Richardson, 1990). Though considered a common saprophyte world wide, in India it was reported to cause heavy losses in chickpea in the states of Bihar, Haryana, Himachal Pradesh, Madhya Pradesh, Punjab and Tamil Nadu (Laha and Grewal, 1983). It causes yield losses in the field and during post harvest storage and transport. Economic losses of more than 50 per cent may occur in many crops, depending on the prevailing environmental conditions and intensive use of fungicides is needed to control grey mould.

Colletotrichum dematium (Pers.) Grove, the causal organism of dieback or anthracnose, has a wide host range. The fungus was intercepted in seven samples, one sample each of *Cicer arietinum*, *Crambe abyssinica* and *Gossypium* sp. from Syria, USA, and UK, respectively and five samples each of *Glycine max* and *H. annuus* from Taiwan and USA. Awasthi and Bhargawa (2000) reported a significant reduction in chickpea production in India due to *C. dematium*.

Curvularia lunata (Wakker) Boedjin was intercepted in 70 samples of paddy from the Philippines (69) and sorghum from the USA (1). Grain mould caused by a complex of *C. lunata* and other fungi like *Fusarium moniliformae* and *Phoma sorghina* has been classified as a high priority disease of sorghum in East Africa, Venezuela and the USA (Hulluka *et al.*, 1992; Teyssandier, 1992; Frederiksen and Duncan, 1992).

Drechslera avenae (Eidam) Sharif, the causal agent of leaf spot or pre-emergence damping off was intercepted in one sample of barley from Australia. The disease is most damaging when cool wet conditions prevail during the early seedling stage and depending on the cultivar and climatic conditions, about 14 per cent yield losses are reported (Kunovski and Breshkov, 1981).

Drechslera maydis (Nisikado and Miyabe) Subram. and Jain, the maydis leaf blight fungus was detected in three samples of maize from Thailand and the Philippines. The fungus possess three races, including a devastating race, Race-T that caused the great epidemic of 1970 in USA due to a large scale planting of cytoplasmic male sterile lines. Earlier, Ram Nath *et al.* (1973) had intercepted Race T of the fungus in sorghum seed from USA. Introduction of exotic and more virulent strains along with the introduced germplasm can pose a serious threat to the indigenous maize cultivars.

Drechslera oryzae (Breda de Haan) Subram. and Jain [= *Cochliobolus miyabeanus* (Ito & Kurib.) Drechsler ex Dastur], brown leaf spot fungus of rice was detected in 16 samples from the Philippines and Bangladesh. Brown spot is a common disease of rice worldwide and can cause considerable yield losses. The disease was the main cause of the Great Bengal Famine of 1942 in India and crop losses during the epidemic year ranged from 50 to 90 % (Padmanabhan, 1973).

Drechslera sorokiniana (Sacc.) Subram. and Jain [teleomorph- *Cochliobolus sativus* (Ito & Kurib) Drechsler ex. Dastur], the causal agent of leaf blight/ seedling blight is the most important foliar pathogen on many crops throughout the world, particularly on wheat and barley. The fungus was intercepted in 33 samples including 29 samples of wheat from Belgium, Mexico, Nepal and USA and one sample each of *B. juncea* from Canada, *Capsicum* sp. from China, *Lycopersicon esculentum* from Taiwan and *Poa pratensis* from USA. Yield losses up to 19 per cent are reported (CABI, 2006). In past, the fungus was intercepted on various crops (Khetarpal *et al.*, 2001) and on *Triticum* spp. alone from 23 countries (Dev *et al.*, 2005). The fungus has many physiological races and geographically remote populations are reported to differ in virulence (Levitin *et al.*, 1985) hence, its interception from various countries is significant from quarantine point of view.

Fusarium moniliforme Sheldon [teleomorph-*Gibberella fujikuroi* (Sawda) Ito] the causal organism of bakanae disease of rice and maize stalk rot was intercepted in 245 samples of 15 crop species from 11 countries. The interception of *F. moniliformae* in five samples out of total 19 samples of *Perilla frutescens,* an under utilized crop introduced from USA is very significant from quarantine point of view. The fungus is reported to infect a large number of crops of economic significance and can survive up to 26 months in infected grains. A variation in virulence is reported in the fungus (CABI, 2006). Yield losses due to bakanae disease ranges from 20-50 per cent in Japan and 15 per cent losses are reported from eastern districts of Uttar Pradesh in India (Ou, 1985).

Fusarium solani (Mart.) Sacc., [teleomorph-Nectria haematococa (Wollenw.) Gerlach], the causal agent of wilt, blight and collar and root rots in a large number of crops was intercepted in one sample each of chickpea, cotton, safflower, tomato from Syria, the USA, Germany and Taiwan, respectively, and two samples of rice from Philippines. Though known to be seed-borne in cotton, in this laboratory, the fungus was intercepted on this host for the first time. During last 25 years, *F. solani* was intercepted in 93 crop species including 65 crop species where the fungus was not known to be seed-borne earlier (Agarwal *et al.*, 2005). *F. solani* causes substantial economic losses in various crops worldwide. Foot-rot syndrome in legumes has been reported as a major limiting factor to crop production causing substantial yield losses in pea and bean crops in Europe and North America. Sudden death syndrome of soybean, an important disease in the southern USA is now becoming more prevalent and severe in northern states also (Scherm and Yang, 1996). Lima and Lopes (1998) reported different levels of aggressiveness between isolates of *F. solani* that attack potato in Brazil. Recent molecular studies also revealed high levels of diversity within the fungus (CABI, 2006).

Macrophomina phaseolina (Tassi) Goid (synonym *Rhizoctonia bataticola* (Taubenh.) Butler), the causal agent of charcoal rot was intercepted in two samples of *G. max* from Taiwan. Charcoal rot is an economically important disease in a large number of crops throughout the world. During last 25 years the fungus was intercepted on several crops from many countries (Khetarpal *et al.*, 2001). Seed infection reduces germination and the pathogen retains viability for 15 months in seeds at room temperature. Significant yield losses are reported in chickpea, groundnut, sunflower, sorghum and soybean (CABI, 2006).

Phoma lingam (Tode) Desm. [teleomorph-*Leptosphaeria maculans* (Desm.) Ces. and De Not], the causal organism of black leg or stem canker of crucifers was intercepted in *B. juncea* from Canada. *P. lingam* is one of the most important pathogens of brassicas and yield losses up to 90 per cent have been reported from Australia, America and Europe (CABI, 2006). The fungus is known to be highly variable and two strains termed as virulent (group A) and avirulent (group B) are being reported which are further known to possess genetically distinct sub-groups (Taylor *et al.*, 1991). Recent studies have revealed that the population structure of the fungus varies in different regions of the world; A-group isolates predominate in Australia, B-group isolates predominate in China and eastern Europe, and isolates are evenly distributed between the two strains in western Europe and North America (West *et al.*, 2002).

Rhizoctonia solani Kuhn was intercepted in 4 out of 5 samples of *Beta vulgaris* from USA and 2 out of 6 samples of *Papaver dubium* from Denmark. It is a pathogen with a worldwide distribution and infects a large number of crops. Yield and economic losses caused by the fungus have not been determined in the majority of crops and environments.

Verticillium albo-atrum Reinke and Berthold, the causal agent of Verticillium-wilt is limited to cool, temperate regions of the world and in India the fungus is mainly present in Karnataka, Rajasthan, Tamil Nadu and Uttar Pradesh (CABI, 2006). The fungus can infect numerous economically important plant species and is seed-borne in 15 crops (Richardson, 1990). Infected planting material is the primary source of introducing the pathogen into disease-free areas. *V. albo-atrum* is known to possess a number of physiological strains and its potential to evolve more virulent strains is the major constrain in the breeding plants for resistance. The fungus was detected in *Capsicum* sp. and *Solanum melongena* (Taiwan), *Carica papaya* (Cuba), *H. annuus* (France) and *Oryza sativa* (the Philippines). *V. albo-atrum* is considered of high economic importance and reported to cause significant losses in hops and lucerne crops in UK and the USA, respectively (CABI, 2006). In addition to these fungi, *Cephalosporium* spp., *Ceratocystis* sp., *Drechslera sorghicola*, *Fusarium culmorum*, *F. dimerum*, *F. semitectum*, and *Phoma* spp. were detected on a large number of crops from various countries.

Xanthomonas campestris pv. *campestris* (Pammel) Dowson, the causal agent of bacterial black rot of crucifers was intercepted in 14 samples of *Brassica* spp. from Canada, Germany and USA. In the past, *X. campestris* pv. *campestris* the was intercepted on brassicas from several countries (Singh *et al.*, 2006). The bacterium is widely distributed throughout the world and can survive in seeds for more than three years. Infected seeds are the primary source of dissemination and more than six virulent strains of the bacterium are known to occur (CABI, 2006). The disease causes severe losses in production and is of great concern in most of the brassica growing regions of the world.

Chemically treated seeds of wheat, barley and triticale grown in PEQN revealed the detection of loose smut caused by *Ustilago segetum* (Pers.) var. *tritici* Jensen in two entries of wheat and covered smut caused by *U. nuda* (Pers.) Legerh. in five entries of barley from International Maize and Wheat Improvement Centre (CIMMYT), Mexico. Infected plants in the field were uprooted and incinerated.

In all, 754 samples of various crops were found to be infected/ contaminated with 35 pathogens. Out of these, 745 samples were disinfected/decontaminated using various salvaging techniques such as mechanical separation (for bunted seeds), ethyl alcohol wash (for samples with bunt and rust spores), hot-water treatment (for samples infected with species of *Alternaria*, *Colletotrichum*, *P. lingam*, *Rhizoctonia* and *X. campestris* pv. *campestris*, etc.) and pesticidal seed treatment/ dip for seeds/ planting material infected with species of *Drechslera*, *Fusarium*, etc.). Nine samples of soybean infected with the downy mildew infection were rejected and incinerated.

It was observed that out of total 865 infection incidences detected in 754 samples (0.05% of the total import), from 23 countries, the highest infection percentage was observed in the samples from the Philippines (55.26%) followed by the USA (16.72%), Thailand (6.24%), Taiwan (5.54%), Canada (4.16%), Australia (2.42%), Germany (2.32%) and rest of the countries (8.50%). Other samples including vegetative propagules and *in vitro* planting material were found to be free from any pathogen. Nine samples amounting to 1.19% of the total infected samples (0.01% of the total import) were rejected and rest were made disease-free and released to the indenters.

Interception of 35 pathogens in 754 samples of various crops from 23 countries is very significant from quarantine point of view as introduction of even a low incidence of seed-borne exotic pathogens or their more virulent strains along with planting material can pose a threat to the indigenous crops. Quarantine thus has a significant role in protecting agriculture from avoidable damage caused by such introductions and in regulating the safe introduction of plant genetic resources.

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References

Agarwal PC, B Singh, U Dev, Indra Rani, Dinesh Chand and RK Khetarpal (2006a) Interception of *Peronospora manshurica* in soybean germplasm imported during 1976-2005. *Curr. Sci.* **91:** 347-350.

Agarwal PC, B Singh, U Dev, Indra Rani, Dinesh Chand and RK Khetarpal (2006b) Seed-borne fungi detected in sugar beet seeds imported into India during the last three decades. *Plant Health Progress* ***doi*** **10.1094/PHP:** 2006-1211.

Agarwal PC, B Singh, U Dev, Indra Rani, KD Joshi and RK Khetarpal (2005) *Fusarium solani* (Mart) Sacc intercepted in introduced germplasm during last twenty-five years. *Indian J. Plant. Genet. Resour.* **18:** 131-133.

Agarwal PC, B Singh, Indra Rani, KD Joshi, AK Maurya and RK Khetarpal (2004) Pathogenic fungi intercepted in introduced germplasm during 2001. *Indian J. Agri. Sci.* **74:** 451-454.

Awasthi D and PK Bhargava (2000) Effect of blight (*Colletotrichum dematium*) on seed yield of chickpea (*Cicer arietinum*). *Indian J. Agri. Sci.* **70:** 45-47.

Brennan JP and GM Murray (1988) Australian wheat disease assessing their economic importance. *Agri. Sci.* **1**:26-35.

CAB International (2006) Crop Protection Compendium. CAB International, Wallingford, UK

Diehl JA, AD Tinline and RA Kochann (1983) Losses in wheat caused by common root rot in Rio Grande do Sul in 1979-81. *Fitopatologia Brasileira* **8:** 507-511.

Dev U, PC Agrwal, B Singh, Indra Rani, Dinesh Chand, KD Joshi and RK Khetarpal (2005) Pathogenic fungi intercepted in *Triticum* species introduced during 1976-2003. *Indian J. Plant Protection.* **33:** 231-134.

Dev U, A Majumdar, PC Agarwal and Ram Nath (1989) Interception of *Fusarium nivale* in exotic wheat (*Triticum* species) germplasm. *Indian J. Agri. Sci.* **59:** 602-603.

Frederiksen RA and RR Duncan (1992) Sorghum diseases in North America In: WAJ de Milliano, RA Frederiksen and GD Bengston (eds) *Sorghum and Millet Diseases: A Second Review.* International Crops Research Institute for the Semi-Arid Tropics, pp 85-91.

Hartman GL, GB Sinclair and JC Rupe (1999) *Compendium of Soybean Diseases.* APS Press, St. Paul, USA, 4th edition, 100 p.

Hulluka M, Mengistu and JPE Esele (1992) Sorghum diseases in Eastern Africa. In: WAJ de Milliano, RA Frederiksen and GD Bengston (eds) *Sorghum and Millet Diseases: A Second Review.* International Crops Research Institute for the Semi-Arid Tropics, pp 21-29.

ISTA (1968) Proceedings of the International Seed Testing Association **33:** 554 p.

Khetarpal RK, KS Varaprasad, A Lal, PC Agarwal and B Lal (2001) Plant Quarantine of germplasm under exchange. In: BS Dhillon, KS Varaprasad, K Srinivasan, M Singh, U Srivastava and GD Sharma (eds) *National Bureau of Plant Genetic Resources: A Compendium of Achievements.* (National Bureau of Plant Genetic Resources, New Delhi, India, pp 90-115.

Khetarpal RK, Ram Nath and SP Lal (1984) A new species of *Drechslera* recorded on seeds of *Eleusine coracana. Indian Phytopathology* **37:** 320-321.

Kunovski Zh and T Breshkov (1981) Field resistance of oat specimens of the world collection to the pathogens of black rust (*Puccinia graminis* Pers. f. sp. *avenae* Eriks & Henn.) and red leaf spot (*Pyrenophora avenae* Ito). *Rasteniev" Nauki* **18:** 118-123.

Laha SK and JS Grewal (1983) A new technique to induce abundant sporulation of *Botrytis cinerea. Indian Phytopathology* **36:** 409-410.

Levitin MM, AN Petrova and OS Afanasenko (1985) Comparative study of *Bipolaris sorokiniana* (Sacc) Shoem. populations based on virulence symptoms. *Mycologiya i Fitopatologia* **19:** 154-158.

Li M, X Zhao, JZ Liu and XC Yang (1992) A preliminary study on the physiological races of soybean downy mildew, *Peronospora manshurica* (Naum) Syd. *Acta Phytopathology Sinica* **22:** 71-75.

Lima MF and CA Lopes (1998) Virulence variation among isolates of *Fusarium solani* on potato. *Fitopatologia Brasileira* **23:** 121-126.

Marcinkowska J (1991) Reaction of soybean cultivars and lines to *Peronospora manshurica. Eurosoya* **7-8:** 59-62.

Mercer PC, NV Hardwick, BDL Fitt BDL and JB Sweet (1991) Status of diseases of linseed in the UK. HGCA Oilseeds Research Review London UK Home-Grown Cereals Authority (Oilseeds) No **OS3:** 76 p.

Ou SH (1985) Rice diseases Slough UK Commonwealth Agricultural Bureaux pp xi + 380.

Padmanabhan SY (1973) The great Bengal famine. *Annual Review Phytopathology* **11:** 11-26.

Plant Quarantine (Regulation of Import into India) Order (2003) In: The Gazette of India Part-II-Section 3-Sub-section (ii), published by Ministry of Agriculture (Department of Agriculture & Cooperation) Notification, New Delhi, dated 18th November 2003 104 p.

Ram Nath, AK Lambat, MM Payak, J Ramani and I Rani (1973) Interception of race T of *Helminthosporium maydis* on sorghum seed. *Curr. Sci.* **42:** 872-874.

Richardson MJ (1990) An Annotated List of Seed-Borne Diseases. ISTA, Zurich, Switzerland, 387 p.

Saini SS (1985) A note on wide-spread discolouration of rice grai in Haryana during Kharif 1979. *Curr. Sci.* **37:** 39.

Scherm H and XB Yang (1996) Development of sudden death syndrome of soybean in relation to soil, temperature and soil water metric potential. *Phytopathology* **86:** 642-649.

Signoret PA, PC Bernaux and B Poinso (1975) Soybean diseases in France in 1974. *Plant Disease Reporter* **59:** 616-617.

Singh B, PC Agarwal, U Dev, Indra Rani and RK Khetarpal (2006) Interception of *Xanthomonas campestris* pv. *campestris* in imported germplasm of brassicas (*Brassica* spp.). during 1976-2002. *Indian J. Agri. Sci.* **76:** 580-583.

Taylor JL, I Borgmann and G Seguin-Swartz (1991) Electrophoretic karyotyping of *Leptosphaeria maculans* differentiates highly virulent from weakly virulent isolates. *Curr. Gene.* **19:** 273-277.

Teyssandier E (1992) Sorghum diseases in South America. *In* WAJ de Milliano, RA Frederiksen and GD Bengston (eds) *Sorghum and Millet Diseases: A Second Review.* International Crops Research Institute for the Semi-Arid Tropics, pp 63-73.

West JS, MH Balesdent, T Rouxel, JP Narcy, YJ Huang, J Roux, JM Steed, BDL Fitt and J Schmit (2002) Colonization of winter oilseed rape tissues by A/Tox and B/Tox *Leptosphaeria maculans* (phoma stem canker) in France and England. *Plant Pathology* **51:** 311-321.

Wrather JA (1997) Soybean disease loss estimates for the top 10 soybean producing countries in 1994. *Plant Disease* **81:** 107-110.