

REVIEW

Current threats to Plant Bio-security and safeguards for Trade and Exchange programs as constraints towards export of Agriculture commodity

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The world has truly become a global village with reference to communication and transport. The globalization of trade and disappearance of tariff barriers in trade (TBT) has opened flood gates of alien species to move around the world at a faster rate and speed. This really poses greater implications in the context of agricultural bio security of a nation. The later part of WTO regime is witnessing mass invasion of pests into newer areas, causing devastation and affecting the economy of many nations. Developing and underdeveloped countries are the most affected in the absence of preparedness to combat the invasion. The alien invasive species not only affect agriculture, horticulture and forests, they are also the cause for major impacts on environment and biodiversity of any country. India suffers from several introductions of exotic pests causing severe economic and environmental losses. To mitigate all these issues of plant bio security, India has several options like, Phytosanitary certificate and additional declaration during import and export, Phytosanitary measures and treatments during trade, pest risk analysis, Post entry quarantine of imported planting materials, different legislative measures, Area of low pest population, Pest/pathogen free area detection before export and notification by NPPO (<https://ppqs.gov.in/>) etc. To promote safe trade of agricultural commodities across trans boundary movement around the world, plant quarantine system posses safeguards to biodiversity of a nation. India has been gradually strengthening its plant bio security system through modernization of network to compete with other bio secure nations.

Keywords: Plant bio security, Phytosanitary measures and treatments, Pest risk analysis, Pest free area

INTRODUCTION

Plant Bio security is an important issue for any country especially India to safeguard food- security, sustainability of farm production and also in protecting livelihood of people. Recently our major concern is to manage many types of invasive alien pest species that enter from different countries. To protect the agriculture biodiversity due to introduction of exotic pests and diseases, all countries have plant quarantine measures. The government has already enforced legislative measures to regulate the introduction of planting materials, plant products, soil and living organisms,

etc. In order to prevent unintentional introduction, establishment and further spread of pests/ pathogens harmful to the agriculture/ horticulture, Govt. has taken many precautionary safeguards. Codex Alimentarius commission (IPPC, 1979) are getting increasingly stringent at international level. Food safety standards have become the most important non tariff barrier. A quality food safety and bio security awareness program has already been launched at all levels—from farmers to the policy makers. Our bio security infrastructure has been more strengthened as compared to earlier.

According to the National Bureau of Plant Genetic Resources (<https://ppqs.gov.in/>), several invasive alien species have been introduced into the country along with grains, seeds and planting material during imports. These introduced pests include Bunchy top of banana, Banana bract and streak viruses, spiraling white fly, American serpentine leaf miner, peanut stripe virus, cotton leaf curl, potato wart, sunflower downy mildew, coffee pod borer

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and invasive weeds like *Lantana camara* and *Phalaris minor* (Sandilyan *et al.* 2018), which were mostly introduced in 1990s. With the increasing intensification of agricultural production, productivity and trade, such invasive alien species will further threaten our crops. A new wheat stem rust pathotype Ug 99 has been causing serious damage in Uganda, Kenya and a few other countries and threatens to reach India. Wheat being our main food under national food security and agriculture economy, India took right steps to prevent entry and establishment of this race in India. We have been facing several challenges to facilitate the trade. The proper history behind development of bilateral and multilateral trade relationship under WTO umbrella in the world is well known to every country (Singh, 2009).

Import/export share of India in the recent past (2017-18).

The volume of trade in plants and plant materials in India continues to grow. According to the statistics, the National Bureau of Plant Genetic Resources (NBPGR) – one of several regulatory authorities in this space – has processed for quarantine clearance 642,671 samples of various crop plants comprising seeds, vegetative propagules, *in vitro* and transgenic materials, of which 499,796 (including 2,447 samples of transgenics) were imported and 142,875 were intended for export. With trade in such material likely to increase in the coming years, it is worth reviewing the legal and regulatory framework governing the import of plants and plant materials into India. (<https://www.lexology.com/library/detail.aspx?slug=4f57e779-3e2d-4bc5-903d-21db04bd8cf1>)

Background concepts of Bio security

According to FAO (<http://www.fao.org>), there is 50% increased demand of food and energy by 2030. The term '**Biosecurity**' broadly describes the process and objective of managing biological risks associated with food and agriculture in a holistic manner (<http://www.fao.org>). In other term, bio security has direct relevance to I. Sustainability of Agriculture II. Public health III. Protection of environment including biological diversity. Since the inception of civilization, man utilized his best possible efforts to domesticate the geographical area as per his needs. It is not just in recent years that the countries are being invaded by alien species, In fact, man started to take the plants and animals wherever he settled. It is not true that all alien species are harmful, even the invasive

species are not so dangerous in their place of origin. The alien species become invasive in newer area due to absence of natural enemies and favorable environmental conditions.

Components of Bio security

(i) Plant life and health security, (ii) Human life and health security, (iii) Animal life and health security, (iv) Environmental protection, (v) Food safety, (vi) Invasive alien species, (vii) Living modified organism. (<https://www.fao.org>)

Factors influencing bio security

(i) Globalization (ii) New agricultural production and processing technologies (iii) Increased trade of agricultural commodities (iv) Legal obligations for signatories of relevant international agreements (v) Increasing travel and movement of people across borders (vi) Advances in communications and global access to bio security information (vii) Greater public attention to biodiversity, the environment and the impact of agriculture on both (viii) Scarcity of technical and operational resources. (ix) High dependence of some countries on food imports. (<https://www.fao.org>)

Ways through which pest/pathogens are introduced into a new locality

(a) The host may be the carrier; (b) The inert materials such as packaging materials may carry resting stages of the microorganism; (c) The insect vectors and birds may transport it; (d) The air currents may carry the pest/pathogen resting structures over long distances; or (e) There may be deliberate, illegal introductions to use them as bio-weapons.

Alien invasive species – impacts and threats

Alien species - (non-native, non-indigenous, foreign, exotic) means a species, subspecies, or lower taxon occurring outside of its natural range and dispersal potential and includes any part, gametes or propagules of such species that might survive and subsequently reproduce (IUCN, 2000).

Alien invasive species - means an alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity. (IUCN, 2000)

Some alien species became beneficial for India

The first record of **Coffee** growing in India is traced back to 1670 in the hills of Chikmagalur, Karnataka and supposed to be introduced from Yemen (Sandilyan *et al.* 2018).

Potato was introduced to Europe from Andes

(South America) by the Spanish in second half of 16th century and Potato was introduced into India in the early 17th century, most likely aboard Portugal ships, and presently a third of world production of potato is harvested in India and China (Sandilyan *et al.* 2018). **Chilli** was introduced into India from Mexico during 15th century and it has become the integral part of Indian culinary. India is the leading producer of Chilli in the world. In India, commercial cultivation of natural (Sandilyan *et al.* 2018). **Rubber** was introduced by the British planters, although the experimental efforts to grow rubber on a commercial scale in India were started during 1873 at the Botanical Gardens, Calcutta, the first commercial *Hevea* plantations in India were established at Thattekadu in Kerala in 1902. There are lots of such economically valuable plant species which originated in India are now spread to all over the world. To site a few examples: Black pepper, Tea, Cardamom, Coconut, Neem and Mango etc. (Sandilyan *et al.* 2018)

Some alien species became harmful

Few devastating incidences which had taken place in the late 17th and early 18th century around the globe are mentioned below:

Great Famine of Irish

Potato was introduced into Ireland during late 17th century. The late blight disease caused by *Phytophthora infestans* completely destroyed potato crop in 1845, which lead to the starvation and death of 1 million people and migration of another 1 million from Ireland between 1845 to 1852. (Kennedy and Johnson, 2006)

Setback of Grapevine industry in Europe

The introduction of Powdery mildew (*Oidium tuckeri*) into Europe was noticed due to import of American grape-vines. To control powdery mildew, root-stocks of resistant varieties were imported from America (1854). However, these grape vines carried *Phylloxera vastatrix*, a root inhabiting aphid of grape vines. To combat this pest, more American vines resistant to Phylloxera were imported, but these additional importation brought with them the downy mildew caused by *Plasmopara viticola* (Fandl, 2018).

Colossal toad menace

The cane toad, *Bufo marinus*, native of central and south America, was introduced into Australia by the sugarcane industry to control two pests, the gray backed cane beetle (*Dermolepida albohirtum*) and frenchie beetle (*Lepidiota frenchi*). 101 toads were imported in June 1935 and within 6 months the

population exploded to 60000 and was released in the cane fields. Initially, the bio-control agent became successful, but later on it caused ecological imbalance replacing the native frogs due to its over population. (Phillips *et al.* 2007).

Green Cancer of Tahiti

The prolific tree *Miconia calvescens* was densely grown in Tahiti's native forests. Miconia is one of the most destructive invaders in tropical rain forest habitats. It posed a serious threat to ecosystems in the Pacific region. *Miconia* sp. was described as the 'green cancer of Tahiti' and the 'purple plague of Hawaii'. Once *Miconia calvescens* was established at a certain place it drastically changed the ecosystem and biodiversity of that environment. (González-Muñoz *et al.* 2015).

Food turned foe

Philippine rice farmers had to loose nearly US\$1 billion in crops due to the invasive golden apple snail, *Pomacea canaliculata* which was originally introduced from South America to south-east Asia around 1980, as a local food resource. The snails were released in the field and became a serious pest of rice (Joshi *et al.* 2001).

Water weeds

African nations spend an estimated US\$60 million annually for the control of alien water weeds, like water hyacinth *Eichhornia crassipes* and water lettuce *Pistia stratiotes*. (<https://niphm.gov.in>).

The Great Bengal Famine

The Great Bengal Famine of 1943 occurred in undivided Bengal (Bangladesh and West Bengal). It is estimated that over three million people died due to starvation and malnutrition. In the rice growing season of 1942- 1943, Brown spot of rice was caused by the fungus *Helminthosporium oryzae* and the outbreak of the disease caused almost complete destruction of the rice crop (97%).

Alien species (exotic pests)

Coffee pests such as Coffee rust, *Hemilia vastatrix*, coffee green scale (*Coccus viridis*), coffee berry borer (*Hypothenemus hampei*) were intruded from Sri Lanka, Coconut eriophid mite (*Aceria guerreronis*) probably from Sri Lanka

Alien invasive species

Spiralling white fly (*Aleurodicus dispersus*) from Sri Lanka / Maldives, Papaya mealy bug (*Paracoccus marginatus*) from Thailand, Cotton mealy bug (*Phenacoccus solenopsis*), *Phalaris minor* and *Parthenium hysterophorus* weeds from USA .

Water hyacinth (*Eichhornia crassipes*) is another such major weed clogging the waterways in India, brought as ornament from Mexico, *Lantana camara* is another introduced, woody weed. Mile-a-minute weed (*Mikania micrantha*) is another invasive weed, which is smothering the forest and plantation vegetation in India. *Salvinia molesta*, an aquatic weed native of Brazil and *Prosopis juliflora*, thorny, exotic weed introduced from Mexico and Caribbean Islands.

The agricultural economy is under threat from exotic pests/ pathogens during exchange of planting materials (Khetarpal and Gupta, 2006). Few examples are mentioned below :

Bacterial wilt and ring rot of potato (*Clavibacter michiganensis* sub sp. *sepedonicum*) Fire blight of apple and pear (*Erwinia amylovora*), Black pod of cocoa (*Phytophthora megakarya*), Powdery rust of coffee (*Hemileia coffeicola*), Sudden death of oak (*Phytophthora ramorum*), South American leaf blight of rubber (*Microcyclus ulei*), Vascular wilt of oil palm (*Fusarium oxysporum* f. sp. *elaedis*), Soybean downy mildew (*Peronospora manshurica*).

Blue mold of tobacco (*P. hyocyami* sub sp. *tabacina*), Tropical rust of maize (*Physopella zaeae*), Barley stripe mosaic virus Coconut cadang cadang (Viroid)

Palm lethal yellowing (Phytoplasma),

Pine wood nematode (*Bursaphelenchus xylophilus*),

Red ring nematode of coconut (*Rhadinaphelenchus cocophilus*), Mediterranean fruit fly (*Ceratitidis capitata*),

Cotton boll weevil (*Anthonomus grandis*) Russian wheat aphid (*Diuraphis noxia*).

The Great Bengal Famine played a major role in opening of Plant Quarantine Stations in important entry points to prevent the entry of exotic pests into India. The GOI realized the importance of Plant Quarantine as first line of defense to prevent the entry of invasive species of planting materials. The potential dangers imposed by invasive species on plant, animal and human health and the ecological and environmental impacts exerted all over the globe, has created awareness on preserving the natural flora and fauna of a nation, and at the same time to promote safe trade, the need for global level coordination in harmonizing the sanitary and phytosanitary measures (SPS) was initiated

through WTO-SPS agreements. The SPS measures are operated through standard setting bodies such as International Plant Protection Convention, Rome for plant health, OIE (Office international des epizooties) for animal health and CAC (Codex Alimentarius Commission) for human health related issues at international level. FAO (Food and Agriculture Organization) realized the potent threat of bio invasion and bio terrorism to safeguard a nation [IPPC. 1979. International Plant Protection Convention. Rome, IPPC, FAO. [revised ; now IPPC. 1997]. The international tourism has also increased risk of introduction of exotic pests into the country. The effects due to introduction of Living Modified Organisms (LMO) and GMO on human, animal and plant health are unknown. Bio-terrorism and Bio warfare are the major emerging issues at international level, which can imbalance the entire nation's economy and growth resulting loss of lives. The agricultural bio security authorities have taken necessary steps towards implementation of regulations, policies, technological competencies and human capacity building to tackle such threats.

Intercepted in Imported Material Not known to occur in India(Khetarpal and Gupta, 2006.)

(i) *Peronospora manshurica*/ Soybean/ USA, (ii) *Uromyces betae*/ Sugarbeet/ USA and Italy,(iii) *Fusarium nivale*/ Wheat/ UK, (iv) Cowpea mottle virus/ Cowpea/ Philippines, (v) Tomato black ring virus/ French bean/ CIAT (Colombia), (vi) *Heterodera schachtii*/ Sugarbeet/ Denmark, (vii) *Anthonomus grandis*/ Cotton/ USA, (viii) *Quadrastichodella eucalyptii*/ Eucalyptus/ Australia.

Pathogens known to occur but the race/ biotype/strain intercepted during trade is not known to occur (Khetarpal and Gupta, 2007) (i)

Helminthosporium maydis/race T/ Sorghum/ USA, (ii) Pea seed-borne mosaic virus/ Broad bean & *Burkholderia solanacearum*/ biovar 3/ Groundnut/Australia

Intercepted on a host on which it was never reported before(Khetarpal and Gupta, 2009)

(i) *Alternaria zinniae*/ Tobacco/ Japan, (ii) *Pseudomonas syringae* pv *syringae*/ *Hibiscus cannabinus*/ Bangladesh, (iii) *Aphelenchoides besseyi* *Stylosanthes hamata*/ Australia, (iv) *Merobruchus columbinus*/ Samanea saman/ UK, (v) *Bruchus ervil* *Acacia brachustachva*/ Australia, (vi) *Pachymerus lacerdae* *Orbygnya phalerata*/ Italy.

Pest Risk Analysis tool to tackle the Invasive Alien Species:

Pest risk analysis (PRA) is a science based tool to tackle the alien pests of concern to any nation while facilitating international trade. PRA is a process which helps to assess the risks of entry, establishment and spread potential of exotic pests. PRA helps to identify the options to prevent the entry and management options in the event of pest establishment (Fig. 1). The international standards brought out by IPPC serve as guidance for carrying out PRA. The importance of International conventions & National regulations, SPS obligations for regulating trade based on pest risk analysis, concept of risk and risk analysis, PRA process for assessing the likelihood of pests being associated with the pathway, transport, its direct and indirect impact in the event of pest establishment, spread and the risk management options to minimize such event to happen. The importance of PRA for market access for new commodities in the international trade through mock exercises.

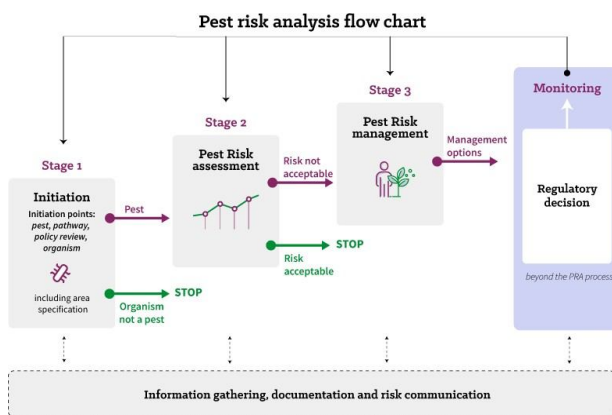


Fig. 1 : Pest risk analysis

Relevant International Legal Instruments and Agreements to give safe guard during trade

In addition to the standards and related texts developed by the CAC (*Codex Alimentarius Commission*), the OIE and the CPM, several other international legal instruments, agreements and texts relevant to bio security are (A) SPS (Sanitary and Phytosanitary) Agreement (B) TBT (Technical Barriers to Trade) Agreement (C) CBD (Convention on Biological Diversity) (D) CP (Cartagena Protocol on Bio safety) (E) International Health Regulations (IPPC. 1997, Reddy, 2016).

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora): CITES is intended to protect endangered species from being collected for export. CITES protects many rare plants and animals from over exploitation and trading. Hence, it is considered as landmark advance in conservation of rare plants and animals and helps to preserve of biodiversity (<https://cites.org/eng/>).

CBD (Convention on Biological Diversity): its objective is to develop national strategies for the conservation and sustainable use of biological diversity. The Convention has three main goals: (i) Conservation of biodiversity (ii) Sustainable use of its components (iii) Fair and equitable sharing of benefits arising from genetic resources (<https://www.cbd.int/convention/>)

CP (Cartagena Protocol on Bio safety): The Bio safety Protocol seeks to protect biological diversity from the potential risks posed by Living Modified Organisms (LMO) resulting from modern biotechnology. (<https://bch.cbd.int/protocol>)

IUCN: The International Union for Conservation of Nature and Natural Resources (IUCN) is an international organization dedicated to finding pragmatic solutions to the most pressing environment and development challenges. The organization publishes the IUCN Red List, compiling information from a network of conservation organizations to rate which species are most endangered. (IUCN,2000)

ISSG (Invasive Species Specialist Group) is established under **IUCN** (International Union for Conservation of Nature). ISSG's network of leading specialists provide technical advice to policy makers, and, ISSG disseminates the most current and reliable information on invasive species ecology, their impacts on biological diversity and ways to prevent and control their spread. (<https://www.eea.europa.eu/data-and-maps/data-providers-and-partners/invasive-species-specialist-group-issg>)

UN-FCCC (United Nations – Framework Convention on Climate Change): The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases. The convention aims to stabilize and eventually reduce global Carbon emissions – an essential step in staving off a probable tidal wave of new

invasions of pests that could be triggered by climate change. (<https://unfccc.int/>)

Agenda 21 is an action plan of the United Nations (UN) related to sustainable development and was an outcome of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992. It is a comprehensive blueprint of action to be taken globally, nationally and locally by organizations of the United Nations System, governments, and major groups in every area in which humans directly affect the environment. (<https://sustainabledevelopment.un.org/content/documents/Agenda21>).

Case study of bio security systems developed in other countries

Norway

Norway has already completed its reform process and established country's food safety administration. On 1 January 2004, the process culminated in the establishment of a 4-pillar reform, represented by the establishment of a new authority; the Norwegian Food Safety Authority, reorganized scientific support pertaining to the food chain through the establishment of an independent risk assessment body, a new Food Law, merging 13 separate Acts and a new clarification of the relevant ministries' constitutional responsibilities. (<https://www.virtualbiosecuritycenter.org/governments/norway/>)

New Zealand

The New Zealand government released its first Bio security Strategy in August 2003. With the bringing together of Bio-security New Zealand with the border services functions of MAF in 2007, MAF Bio security New Zealand was created. The New Zealand played a role model in formulating a Bio security Act in 1993 itself, well ahead of the global need. (<https://www.mpi.govt.nz/biosecurity/>).

Australia

Bio security of Australia is the unit within the Bio security Services Group, in the Department of Agriculture, Fisheries and Forestry, responsible for recommendations for the development of Australia's bio security policy. Bio security Australia provides science based quarantine assessments and policy advice that protects Australia's pest and disease status and enhances Australia's access to international animal and plant related markets. (<https://www.biosecurity.gov.au/>)

USA

In USA Agricultural bio security is looked after by the Animal and Plant Health Inspection Service

(APHIS) headed by an 'Administrator' under the US Department of Agriculture. The APHIS constitutes various divisions including animal care, plant protection and quarantine, biotechnology regulatory services, wild life service etc. supported by the office of emergency management and homeland security as well. The Department of Homeland Security was created in 2002 with as many as 22 agencies including the US Department of Agriculture's Animal and Plant Health Inspection Service. (<https://www.state.gov/biosafety-and-biosecurity/>)

Wheat Blast has threatened the plant bio-security in many countries

Wheat blast (WB) caused by *Magnaporthe oryzae* pathotype *Triticum* (MoT) is an important fungal disease in tropical and subtropical wheat production regions. The disease was initially identified in Brazil in 1985, and it subsequently spread to some major wheat-producing areas of the country as well as several South American countries such as Bolivia, Paraguay, and Argentina. In recent years, Wheat Blast has been introduced to Bangladesh and Zambia via international wheat trade, threatening wheat production in South Asia and Southern Africa (Fig. 2) with the possible further spreading in these two continents (Singh, 2017)



Fig.2: Intercontinental spread of wheat blast attributed to grain trade

Wheat blast affected areas of Bangladesh and West Bengal have been depicted in Fig.3. Wheat Blast symptoms development caused by *Magnaporthe oryzae* have been illustrated in Fig.4.

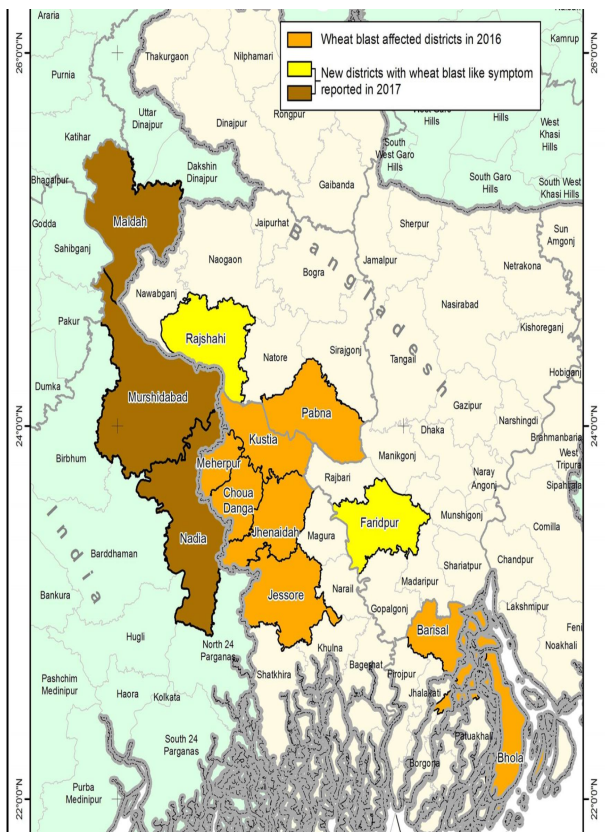


Fig. 3: Wheat Blast affected areas of Bangladesh and West Bengal (2016-2017) (Source: Mottaleb *et al.*, 2018)



Fig. 4: Wheat Blast symptoms caused by *Magnaporthe oryzae* (A) Eye-shaped lesions with light grey centres and (B) dark brown spots on a severely blast infected wheat leaf, (C&D) complete bleaching of a wheat spike above the point of infection by blast fungus. (Source: Mottaleb *et al.*, 2018)

Polyphylatic nature of *Pyricularia* has been resolved by Klaubauf *et al.* (2014). Three different types of spores of *Pyricularia* sp. have been presented in Fig.5. Wide host range of wheat blast pathogen has been documented in Fig.6.

International efforts to facilitate the safe trade

The **GATT** is an international trade agreement whose objectives were (a) to raise standards of living; (b) to achieve full employment; (c) to develop the world's resources; (d) To increase production and exchange of goods; (e) to promote economic

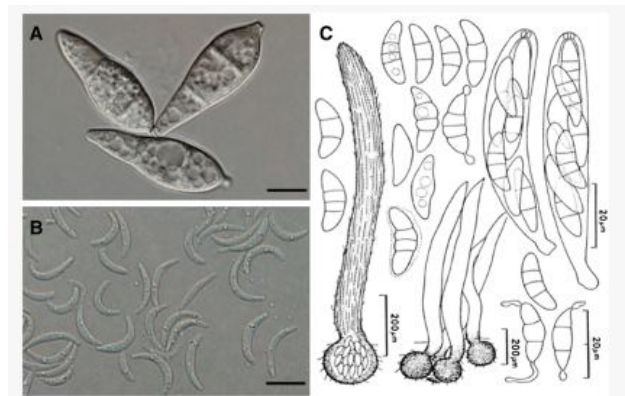


Fig. 5: Spores of *Pyricularia* sp. (A) Asexual pyriform conidia (B) Asexual micro conidia (C) Perithecia and ascospore

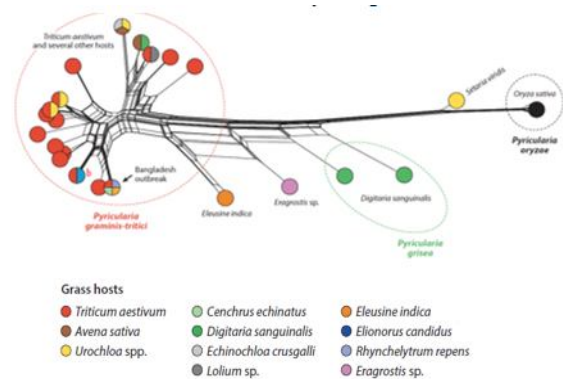


Fig. 6: Wide host range of wheat blast pathogen

development (Baldwin, 2016). The purpose of GATT was substantial reduction of tariffs and other trade barriers and elimination of preferences on a reciprocal and mutually advantageous basis (Trachtman,2002). In Tokyo round first focus was concentrated on non tariff trade barriers (technical barriers to trade or TBTs). In Uruguay round 1986-1994 there was creation of WTO and agreement on the application of Sanitary and Phytosanitary measures (SPS) agreement. The SPS agreement came into force with establishment of WTO on 1st January,1995.

India had been a WTO member since 1 January 1995 and a member of GATT since 8 July 1948.To join the WTO, every government of member country had to bring its economic and trade policies in line with WTO rules and negotiate its terms of entry with the WTO membership. The WTO has over 160 members representing 98 per cent of world trade. Over 20 countries have been seeking to join the WTO. The SPS Agreement concerns the application of food safety and animal and plant health regulations (Baldwin, 2016).

WTO-SPS agreement recognizes the following three international standard setting agencies: (i) For food safety-human health Codex alimentarius commission (CAC), HQ- Viena, (ii) For animal health and zoonoses- International office of Epizootics (OIE), World organization for animal health, HQ- Paris, (iii) For plant health: International Plant Protection Convention (IPPC), HQ- Rome.

IPPC The International Plant Protection Convention (IPPC) is an international treaty organization that coordinated a “Phytosanitary Agreement” for protecting agriculture from pests that could spread through international trade in plants and plant produce. Member countries are supposed to maintain inspection procedures for export and undertake eradication and control measures in the event of new pest infestations occur. It was decided during agreement that, Member countries require to establish NPPO (National Plant Protection Organization) to promote safe agricultural trade and to protect natural flora. The first effort towards international agreement on Plant Protection was made in 1914 under auspices of the International Institute of Agriculture in Rome. This was followed by an International Convention on Plant Protection by over 50 member countries of the Institute in 1919 and certain Agreement regarding the issue and acceptance of Phytosanitary Certificate were finalized (<https://www.ippc.int>).

Importance of Phytosanitary certificate (PSC) and import permit (IP) (Plant Quarantine Order, 2003)

PSC & IP – 2 documents which serve different purpose but directly related to Phytosanitary condition of the plants

PSC - issued by exporting NPPO - plant health certificate after carrying out inspection, sampling and testing, if required treatment.

IP - issued by importing country - pre-entry condition (which clearly spells out requirement of importing country).

Article IV, V & VII of IPPC – Phyto-Sanitary certification and issuance of import permit.

Article IV, states that NPPO is responsible for issuance of Phyto-Sanitary certificates.

Appreciating the need for the Convention to

strengthen such international efforts, FAO sponsored an International Plant Protection Convention in 1951. India became a member in 1956 and agreed to adopt legislative measures specified in the Convention for the purpose of securing common and effective action to prevent the introduction and spread of pests and diseases of plants and plant materials and to promote measures for their control.

IPPC Activities

(i) International standard settings (ISPMs), (ii) Information exchange, (iii) Dispute resolution, (iv) International cooperation in pest/pathogen eradication and management (v) Technical assistance (vi) Capacity building. (The ISPMs are available on the International Phytosanitary Portal (IPP) at (<https://www.ippc.int>))

IPPC’s Strategic Goals (2012-2019)

(A) To Promote the sustainable agriculture and the global food security through the prevention of pest spread. (B) To Protect the environment, forests and biodiversity from plant pests. (C) To Facilitate the economic and trade development through the promotion of harmonized scientifically based phytosanitary measures. (D) To Develop the phytosanitary capacity for members to accomplish A, B and C (<https://www.ippc.int>)

The Commission on Phytosanitary Measures (CPM) was established in 2005 building on the Committee of Experts on Phytosanitary Measures (CEPM), whose first session was held in 1993. The CPM is the IPPC main governing body. The CPM promotes the full implementation of the Convention’s objectives, including reviewing the state of plant protection in the world and actions to control the international spread of pests and their introduction into endangered area. (<https://www.ippc.int>)

International Standards for Phytosanitary Measures (ISPMs) were adopted by the Commission and come into force once countries establish aligned requirements within their national legislation. ISPM working principle during Trade has been presented in Fig.7. The standards of the IPPC are recognized as the basis for phytosanitary measures applied in trade by the Members of the WTO. (<https://www.fao.org/3/i2080e/i2080e09>)

ISPM1	Principles of plant quarantine as related to international trade	1995
ISPM2	Guidelines for pest risk analysis	1996
ISPM3	Code of conduct for the import and Release of exotic biological control agents	1996
ISPM4	Requirements for the establishment of pest free areas	1996
ISPM5	Glossary of Phytosanitary terms	2001
ISPM6	Guidelines for surveillance	1997
ISPM7	Export certification system	1997
ISPM8	Determination of pest status in an area	1998
ISPM9	Guidelines for pest eradication programs	1998
ISPM10	Requirements for the establishment of pest Free places of production and pest free production sites	1999
ISPM11	Pest risk analysis for quarantine pests including	2001
ISPM12	Environmental risks and LMOs Guidelines for Phytosanitary certificates	2001
ISPM13	Guidelines for the notification of non- Compliance and emergency action	2001
ISPM14	The use of integrated measure in systems	2002
ISPM15	Approach for pest risk management Guidelines for regulating wood packaging	2002
ISPM16	Material in international trade Regulated non-quarantine pests: Concept and Application	2002
ISPM17	Pest reporting	2002
ISPM18	Guidelines for the use of irradiation as a	2003
ISPM 19	Phytosanitary measure	2003
ISPM20	Guidelines on list-of regulated pests Guidelines for Phytosanitary import regulatory system	2004
ISPM21	Pest risk analysis for regulated non-quarantine pests	2004
ISPM22	Requirements for the establishment of areas of low pest prevalence Guidelines for inspection	2005
ISPM23		2005
ISPM24	Guidelines for the determination and recognition of Equivalence of Phytosanitary Measures	2005

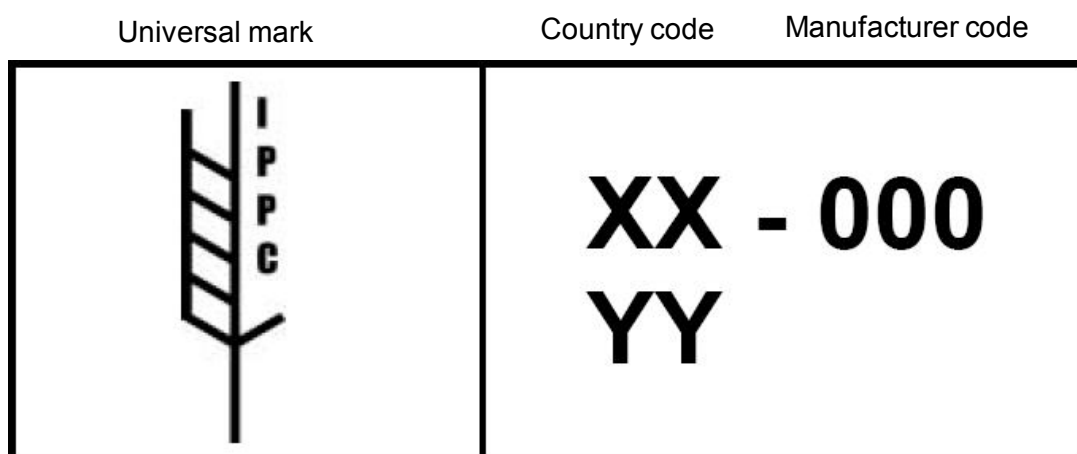


Fig. 7: ISPM working principle during Trade

There are ten regional plant protection organizations who are involved in monitoring plant biosecurity (Fig. 8.).The following twenty five countries are currently members of the Commission.

Australia, Bangladesh, Cambodia, China, Democratic People's Republic of Korea, Fiji, France, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Samoa (Western), Solomon Islands, Sri Lanka, Thailand, Timor-Leste, Tonga, Vietnam.

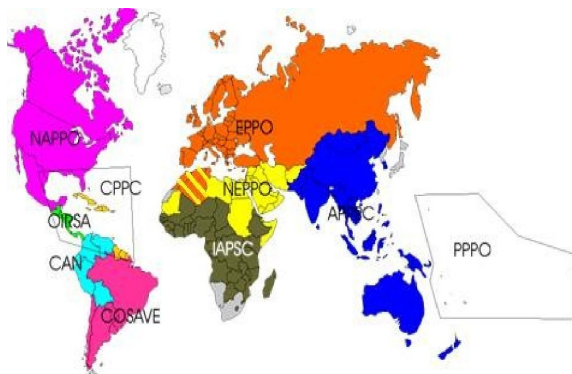


Fig. 8: Regional plant protection organizations (RPPOs) to monitor Plant biosecurity

(APPPC)Asia and Pacific Plant Protection Commission , (CAHFSA) Caribbean Agricultural Health and Food Safety Agency, (CAN) Comunidad Andina, (COSAVE)Comite de Sanidad Vegetal del Cono Sur, (EPPO)European and Mediterranean Plant Protection Organization, (IAPSC)Inter-African Phytosanitary Council, (NEPCO) Near East Plant Protection Organization , (NAPPO)North American Plant Protection Organization, (OIRSA) Organismo Internacional Regional de Sanidad Agropecuaria, (PPPO) Pacific Plant Protection Organization

The Asia-Pacific Plant Protection Commission (APPPC) was convened in 1956 and administers the Regional Plant Protection Agreement for Asia and the Pacific.(IPPC. 1979. International Plant Protection Convention. Rome, IPPC, FAO.)

Plant quarantine acts as safeguard but not as barrier to trade activity. The plant quarantine system is the first line of defense against the introduction and possible establishment of exotic plant pests. Plant Quarantine laws, regulations and services are based on national and international agreements, which evolved during nineteenth and twentieth century around the world. These were formulated on agricultural and economic needs. There is a historical background for the creation of PQ system.

Regulations enacted at International level

The very first regulations were enacted by **French Government** in 1913 but came into effect only in 1923 (Macleod *et. al*, 2010)

The **German Government** started to put ban on plants and plant products from USA in 1913 (<https://www.ippc.int/en/countries/all/legislation/>) In **USA**, the PQ work started well ahead in 1891 when the State of California initiated seaport inspection at San Pedro, probably the first in the world. The Federal Plant Quarantine Act was enacted in 1912 (<https://www.ippc.int/en/countries/all/legislation/>).

Indonesia enacted a law to prohibit importation of coffee plants and beans from Sri Lanka in 1877 (<https://www.ippc.int/en/countries/all/legislation/>)

In **Australia** the first set of regulations governing PQ came into force on 1909 following introduction of the Quarantine Act of 1908 (<https://www.ippc.int/en/countries/all/legislation/>).

In **India** the first regulation – the Destructive Insects and Pests Act, 1914 came into force Now almost all the countries have PQ regulations in force (<https://www.ippc.int/en/countries/all/legislation/>)

Import regulations in India

- 1914 – Destructive Insects and Pests Act, 1914
- 1936 - Import Regulations
- 1972 – Regulations to import cotton
- 1984 – PFS Order, 1984
- 1988 – National Policy on Seed Development
- 1989 – PFS Order, 1989 (revised)
- 1992 – Amendment to DIP Act – for levying import inspection fee
- 2003 – Plant Quarantine (Regulation of Import into India) Order, 2003

Plant Quarantine Regulations of Import into India Order, 2003 (PQ Order, 2003)

It was notified under the DIP Act and came into force with effect from 1st January, 2004. The PQ Order, 2003 replaces all the preceding Orders / notifications of plant quarantine regulations. PQ Order, 2003 was formulated on the scientific basis of Pest Risk Analysis (PRA). The commodities are categorized into various Schedules based on associated pest risk either through pathway or from

countries where the pest is known to be reported. The order clearly spells out notified points of entry, list of prohibited, restricted, regulated commodities, quarantine weeds of concern to India, Inspection fee, authorities to issue import permits, to certify post entry quarantine facilities (PEQ) and the deposition of samples to gene bank of NBPGR. Within this PQ order, 2003, under different schedules, different legislation were formulated.

Schedule I: List of Entry Points

Schedule IV: List of Plants/Planting material whose import is prohibited

Schedule V: List of Restricted Items whose import requires Authorization + Special Conditions + Additional Declaration

Schedule VI: Restricted Items whose import requires Special Conditions + Additional Declaration

Schedule VII: Items whose import is permitted based on Phytosanitary certificates

Schedule VIII: List of quarantine weeds

Schedule X: Import Permit issuing authorities

Action taken by NPPO (India) during the XII Plan Period (<https://ppqs.gov.in/>)

- The Agricultural Bio security Bill was been approved by the Cabinet and has been introduced in Parliament on 11th March, 2013.

- Development & Strengthening of facilities existing 36PQ Stations

- Establishment of PQ Stations at the Notified Points of Entry:

- Development of an Integrated Export Certification System:

- Development of an Integrated Phytosanitary Border Control System:

- Development of an Integrated Information Management System:

- Establishment of Molecular Diagnostic facilities:

- An integrated pest risk analysis system and a national pest risk analysis unit for conducting integrated pest surveillance.

- Strengthening of Integrated Pest Surveillance System:

- Strengthening of Human Resource Development

(HRD)Cell:

- Strengthening of XRay Baggage Scanners (organic) at the International Terminals of Major Airports:

- ISO certification during 2008-09 for improving delivery of services. Tuticorin PQS was ISO certified during 2010-11.

- Online computerized plant quarantine system was launched successfully.

- Round the clock (24x7) plant quarantine services have already been introduced at Chennai, Mumbai, New Delhi, Kolkata, Amritsar and Thiruvananthapuram.

- Online computerized plant quarantine system has been launched

- Strengthening of Taxonomy Unit

Phytosanitary treatments during the process of trade also give safeguard to bio-security

The removal of quantity restrictions has enhanced bulk trade of agricultural materials across the globe. Bulk trade results great threat to the bio security of a nation, as exotic pests can easily enter into newer areas. It is true that 'zero' tolerance cannot be achieved in trade of agricultural materials. It is the responsibility of the importing country to safeguard from incursion of exotic pests (Quarantine pests) to safeguard food security of that nation. The responsibility of the exporting country to take care that, there materials are not the means for spreading pests into importing country. Thus, it is important that both countries need to implement PQ regulations and respect each other's phytosanitary requirements and promote safe, smooth and predictable trade. There are many types of phytosanitary treatments in practice as of now. The methods of such phytosanitary treatments are mentioned below. (<https://niphm.gov.in>)

Post harvest phytosanitary treatments act as filter during trade activities

Hot water immersion treatment (HWIT) (<https://niphm.gov.in>) Vapor heat treatment (VHT) (<https://niphm.gov.in>),

Dry heat treatment (DHT) (<https://niphm.gov.in>),

Forced hot-air heating treatment (FHAT) (<https://niphm.gov.in>)

niphm.gov.in) For treating perishable commodities (https://niphm.gov.in),

For treating Timber logs and Wood packaging Materials (Areas, 2005), Cold treatment (https://niphm.gov.in), Irradiation (https://niphm.gov.in) Fumigation (https://niphm.gov.in),

Treatment of perishable commodities (https://niphm.gov.in)

Fumigation by Methyl bromide (100% MBr) is being used for some fresh commodities as phytosanitary measure in few countries against insect pests, including fruit flies. In India, Chloropicrin (2%) is added as a warning agent to MBr. Chloropicrin is phytotoxic and hence, MBr fumigation for fresh produce is not carried out in India.

Treatment of non-perishable commodities (https://niphm.gov.in)

Commodities such as dry grains, pulses, cereals, timber logs, wood packaging materials, other plant materials can be fumigated with MBr or Aluminium Phosphide (AIP) to render pest free. Dipping/ drenching/ fogging/ dressing etc using pesticides (https://niphm.gov.in)

PFA and ALPP to strengthen plant bio security during trade

Pest Free Area (PFA): An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained [FAO, 1995].

PFA are of three types:

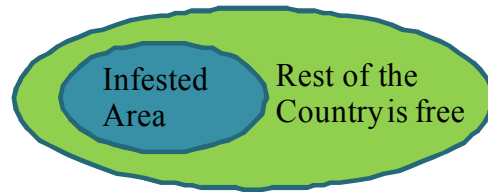
(i) An entire country freedom for a specific pest



SALB– South American Leaf Blight of Rubber, Lethal Yellowing of Coconut, Coconut Cadang-Cadang viroid

(eg. South American Leaf Blight of Rubber, Lethal Yellowing of Coconut, Coconut cadang cadang viroid)

(ii) An uninfested part of a country in which a limited infested area is present (eg. Potato Wart in Darjeeling, Codling moth in Ladakh, Potato cyst nematode in Nilgiri hills & Coffee berry borer in Karnataka, Tamil Nadu & Kerala)



Potato wart (Darjeeling), Codling Moth (Ladak), Potato Cyst Nematode (Nilgiris, Shimla), Coffee Berry Borer (Kerala, Karnataka & Tamil Nadu)

(iii) An uninfested part of a country situated within a generally infested area (eg. Mango stone weevil in Saharanpur, UP, & Brown rot of Potato in Punjab)(Areas,2005).



Mango Stone weevil- Saharanpur (UP), Brown rot of Potato- Punjab

PFA is used as an alternate risk management option for phytosanitary certification of plants and plant products and other regulated articles exported from the exporting country. PFA has its three components, 1. System to establish freedom, 2. Phytosanitary measures to maintain freedom, 3. Review to verify maintenance of freedom.

Area of Low Pest Prevalence (ALPP) to facilitate safe trade during export An area, whether all of a country, part of a country, or all or parts of several countries, as identified by competent authorities, in which a specific pest occurs at low levels and which is subject to effective

surveillance, control or eradication measures (Areas, 2005).

Case study on ALPP in case of Mediterranean Fruit Fly for papaya from Central America Fruit fly trapping at a rate of one trap per hectare beginning at least one year prior to harvest and continuing through completion of harvest.

The traps are serviced weekly and if the capture rate exceeds seven Mediterranean fruit flies per trap per week (F/T/D=1), then remedial action must be taken to reduce the fly population, If catches exceed F/T/D=2, all exports are suspended, ALPP and Systems approach offer possibilities to produce (and export) from areas that are not pest free.

It does require research to develop methods and a lot of cooperation between NPPO's of exporting and importing countries. There are many examples regarding fruit flies, but much less for other pests and diseases

Post Entry Quarantine (PEQ) facility also gives safeguard during import (PQ Order, 2003).

The inspection authority of concerned area of jurisdiction or any officer authorized by the Plant Protection Adviser in this behalf, in association with a team of experts shall inspect the plants grown in the approved post-entry quarantine facility at such intervals as may be considered necessary in accordance with the guidelines issued by the Plant Protection Adviser (Head of NPPO), with a view to detect any pests and advise necessary phytosanitary measures to contain the pests. The inspection authority shall permit the release of plants from post-entry quarantine, if they are found to be free from pests and diseases for the period specified in the permit for importation. Where the plants in the post-entry quarantine are found to be affected by pests and diseases during the specified period the inspection authority shall:-

(i) order the destruction of the affected consignment of whole or a part of the plant population in the post-entry quarantine if the pest or disease is exotic, or

(ii) advise the importer about the curative measures to be taken to the extent necessary, if the pest or disease is not exotic and permit the release of the affected population from the post-

entry quarantine, Otherwise, the plants shall be ordered to be destroyed.

National efforts to prevent entry of invasive alien species

Plant Quarantine System

The Plant Quarantine (Regulation of Import into India) Order, 2003 is aimed at preventing the entry, establishment and spread of alien invasive species into India through plant quarantine mechanism. Plant quarantine acts as the first line of defense at the entry points(<https://ppqs.gov.in/>).

Germplasm Exchange

The incursion of dangerous pests coming through the germplasm material is monitored by NBPGR (National Bureau of Plant Genetic Resources) (<https://ppqs.gov.in/>)

Research Institutes

The crop research institutes of ICAR (Indian Council of Agricultural Research) are responsible for monitoring the planting materials imported for research to prevent entry of alien invasive species(<https://ppqs.gov.in/>).

Bio security Authority

The Government of India has already taken initiative towards establishing NABS and in near future the same shall come into force(<https://niphm.gov.in/>).

Surveillance

As of now surveillance is carried out by individual departments, governments, institutes, NGOs, individuals etc. without much network and information sharing. Surveillance mechanism needs to be integrated with Bio security Authority to know pest status and carry out eradication programs in the event of pest incursion (Areas, 2005).

Pest Diagnosis

Precise identification of pest is a major concern in the event of exotic pest incursion or new pest reports. Human resource and centralized pest repository are the major thrust area, which needs strengthening. The past bitter and costly

experiences gathered due to the impact of introduced invasive species has led to the awakening of plant battle field to combat the entry of invasive alien weeds and other species which might topple the economy, destroy the ecology, and disturb the environment of India. Stringent legal regulations, public awareness, coordinated efforts by the scientific and farming community with administrative backup, preparedness with eradication measures in case of entry, instant sharing of notice of invasive weeds through network among states and central to take appropriate action at appropriate time etc. are all the need of the hour to combat entry of invasive weeds(<https://ppqs.gov.in/>).

CONCLUSION

At present every country has special interest to develop plant bio-security related infrastructures of its own. Naturally, if any sudden outbreak of plant disease takes place, these countries are prepared to respond quickly. In the recent past, COVID-19 has opened our eyes. In case of sudden outbreak of any pandemic due to plant disease, not only the scientists, but also the policy makers and administrators must be well prepared to tackle the unwanted situation effectively. Sufficient regulatory mechanisms and quarantine facilities and rapid molecular detection techniques are now widely available at national and international level to restrict the entry, establishment and spread of exotic pests and pathogens. But, at the same time more emphasis should be given on the development of immunity in the healthy population of the crop which are not yet affected. In addition, we have to give more emphasis on phytosanitary measures and treatments. In this way, we can combat any type of threat developed during the exchange of planting materials.

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