

Cost of Plant Introduction -The Expanding Horizons of Crop Diseases

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Inadvertent movement of plant pathogens into new ecological regions from their original home creates an alarming signal by causing threat to plant biodiversity. All the historical evidences indicate that the introduction of invasive alien species (IAS) is the major driver behind the appearance of new disease, resurgence and spread of indigenous pathogens and pathotype strain selection which ultimately adds cost to the plant introduction. This calls for designing a suitable policy which can restrain the ingress of pathogens into a new ecological niche through plant introductions. But, considering the enormity of the ecological regimes in India and the dynamics of the international agri-trade policy, plant quarantine regulations would be constrained due to the increased possibilities of the spread of pathogens. Preventive domestic quarantine needs to be considered along with strict Pest Risk Analysis (PRA), so that aggravated risk to ecological biodiversity and cost of plant introduction could be reduced.

Key words: Invasive pathogens, Quarantine, Plant introduction

The invasive alien species (IAS), many of which are plant pests and pathogens, assume significance as threat to biodiversity (Khetarpal and Gupta, 2004a). Several thousand of species have moved globally and out of every 7 species, atleast one becomes invasive. Biological invasions due to plant pathogens have a long history and devastating effect (Kiss, 2005). Food security of the nations depend upon agriculture and sustainability has been affected by plant pathogens, because crops are vulnerable to diseases. Frequently indigenous or introduced pests and pathogens have jeopardized production in many parts of the world, with serious economic consequences in terms of increased cost of sustained management and loss of export markets (Ambrose, 1996).

The number of diseases which moved inadvertently in to new ecological regions from their original habitats have increased over the years due to the increased mobility of men and materials. Probability of plant pathogens becoming invasive on plant introduction increases in intensive agro-ecosystems, which has gradually become a reality from 19th century onwards (Fig. 1). In the augment trade regime, probability of inadvertent introductions of pathogens can also increase and plant quarantine as crop protection strategy thus faces an enormous challenge in future.

Recent example is the introduction of Karnal bunt of wheat in USA in spite of the stringent regulations and considerable investments to prevent the entry of the pathogen (*Tilletia indica*). The Karnal bunt pathogen was detected in USA in 1996 (Ykema, 1996), after about 25 years of its detection in Mexico in 1972 (Duran,

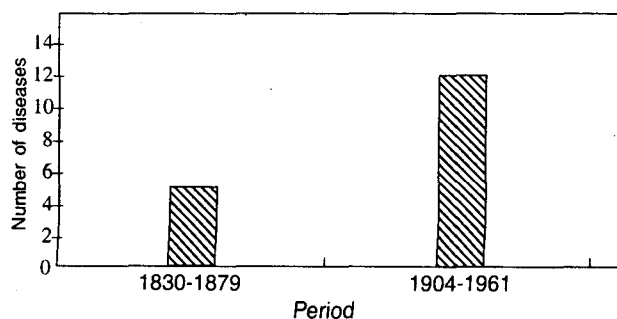


Fig. 1: Number of diseases of crop plants which moved into new locations from 1830-1961

1972) indicating “inadequacy of the quarantine efforts to prevent entry of pathogens in to new locations” with the methods used. This calls for introspection because “the expanding horizons of plant pathogens remains a reality” (Table 1).

With this continued introduction of pathogens, the critical aspects of which need to be re-examined are that the legislative measures of the Plant Quarantine as tools to prevent entry of pathogens in to new ecological niches, because

- The Plant Quarantine Regulations emphasize the movement of disease free planting material but till date non-indigenous pathogens have remained an important issue.
- The ability of the “endemic low profile pathogens becoming severe on the introduction of exotic plant material” has not been considered.
- Now with World Trade Organization having legalized farm trading under various treaties, and in the current global scenario the international quarantine

Table 1. Some important diseases inadvertently introduced in to new locations

Disease	Organism	Introduced in	From	Year
Leaf blight of potato	<i>Phytophthora infestans</i>	Latin America	Europe	1830
		India	Europe	1883
Powdery mildew of grapes	<i>Uncinula necator</i>	England, Europe	USA	1845
Downy mildew of vines	<i>Plasmopara viticola</i>	France	USA	1845
Leaf rust of coffee	<i>Hemelia vastatrix</i>	India	Sri Lanka	1879
Chestnut blight	<i>Endothia parasitica</i>	USA	Asia	1904
Flag smut of wheat	<i>Urocystis tritici</i>	India	Australia	1906
Citrus canker	<i>Xanthomonas citri</i>	USA	Asia	1907
Blister rust of pine	<i>Cronartium ribicola</i>	USA	Europe	1910
Downy mildew of grapes	<i>Plasmopara viticola</i>	India	Europe	1912
Potato scab	<i>Streptomyces scabies</i>	Korea	Japan	1913
Downy mildew of maize	<i>Sclerospora phillipinesis</i>	India	S-E Asia	1918
Onion smut	<i>Urocystis cepulae</i>	Switzerland	France	1924
		India	Europe	1958
Tobacco black shank	<i>Phytophthora nicotianae</i>	India	South east	1938
Bunchy top of banana	Viral	India	Sri Lanka	1940
Bacterial canker of tomato	<i>C. michiganensis</i>	England	USA	1942
Golden nematode of potato	<i>Heterodera rostochinesis</i>	India	Europe	1961
Downy mildew of sunflower	<i>Plasmopara helstedii</i>	India (hybrids seeds)	Russia	1985
Karnal bunt of wheat	<i>Tilletia indica</i>	USA	Mexico	1996
Strawberry leaf spot	<i>Xanthomonas fragariae</i>	Netherlands, France	Belgium	1998

restrictions on the movement of agricultural commodities have to be justified as per the “potential impact”, which must be based upon the bionomics and epidemiology of the pathogens, so as to facilitate free trade in farm produce.

International Plant Protection Convention (IPPC), entrusted for developing international phytosanitary regulations bases its decisions on pest risk analysis (PRA) and information on pest free areas, PFA (Khetarpal and Gupta, 2002; Gupta *et al.*, 2002). Similarly the certification for seed borne pathogens was also based upon the impact on yields (Khetarpal, 2004b).

But the Sanitary and Phytosanitary (SPS) measures in future are likely to remain under increased compulsions to facilitate farm produce trade. Hence at this stage, there is an urgent need to look at the phenomena of plant introduction (intentional or inadvertent) as form of biological invasions and its consequences more objectively on a long term basis. When plant introductions are made in the new environment, the plants are released from the indigenous pathogen pressures and:

- i) if the environment was favourable, the plant itself may assume an invasive role, or succumb to the endemic pathogens; or
- ii) select strains of minor pathogens, changing the pest and disease scenario of the colonized environment.

When plant introductions are made through germplasm exchange, the materials, which are infected, are likely to get eliminated or salvaged, but when a

virgin disease free planting material, unchallenged with local pathogens is considered for planting, at times it may become more susceptible due to absence of resistance against indigenous pathogens.

Recent resurgence and emergence of minor pathogens on the cereal crops in India was because of the extensive plant introductions made during the initial stages, which ushered in the onset, later accelerated and finally to sustained the green revolution. As a consequence, minor pathogens have assumed significance and the situation was well illustrated with cereals and cotton in India, where number of “minor diseases and pests emerged and resurged in last 40 years. Like Karnal bunt and leaf blights in wheat and bacterial leaf blight (BLB), sheath rot, sheath blight, false smut and brown spot in rice and grain discolorations due to facultative pathogens in both have assumed significance”, after the new dwarf varieties were released for cultivation in the farmers field since 1960’s (Table 2). Although data on the virulence changes with respect to most of the obligate pathogens affecting the grain crops was available, nothing much was known about the virulence spectrum or mating types prevalent or introduced in case of the facultative pathogens which became major problems during this phase.

Karnal bunt of wheat and kernel smut of rice are endemic to northern India. Sheath blight was first reported from Japan in 1910 and was important in the Philippines, BLB was originally important in Maharashtra since 1951.

Table 2. Minor diseases of wheat and rice which became major in India

Disease	Crop/Variety	Pathogen	Severe in
Karnal bunt of wheat	Dwarf wheat	<i>Tilletia indica</i>	1976
Leaf blight of wheat	High yielding var	<i>Bipolaris sorokinana</i>	1996
Sheath blight	IR 8 rice	<i>Rhizoctonia solani</i>	1968
Bacterial leaf blight in Punjab	Taichung native 1 (Formosan var)	<i>Xanthomonas campestris</i>	1966
	PR 114	New pathotype of <i>X. campestris</i>	1999
Kernel smut of rice	PR 112, PR 113	<i>T. barclayana</i>	1997

The domains of endemic diseases mentioned above have increased, further aggravating the situation, with the introduction of new varieties and crops. The pathogens like *T. indica*, which were endemic to the foot hills of north India, colonized all the niches in the north western plain zone. Spatial domain increased and resurgence in case of Karnal bunt of wheat was due to the susceptibility of the dwarf wheat or introduction of the new pathotype, which was never investigated. But the disease did create an economic impasse for wheat exports from north western India when production started increasing from early nineties and the disease had yet not entered USA. Only after it was detected in USA in 1996, need for reasonable quarantine against *T. indica* was suggested on IPPC recommendations. Embargo on Indian wheat due to the presence of this pathogen remains till date even in the neighbouring countries, where the disease is prevalent.

Phytophthora infestans, which caused late blight of potato, remained under control in USA till 1970, with the help of fungicides and use of resistant genotypes, after its emergence in 1880's. But it resurged due to the introduction of the complementary mating type in indigenous population, the pathogen had earlier migrated from Mexico and thrived clonally and all of a sudden the disease resurged in USA in 1980s. By 1990, it became berserk and profitability went down rapidly. The new pathotype of *P. infestans* from Mexico, helped in generating new genotypes of the pathogen, due to sexual recombination which had the ability to adapt to the fungicides and resistance deployed (Deahl *et al.*, 1993).

Invasive nature of powdery mildews was well illustrated with *Erysiphe necator* invasions into Europe from USA in the 19th century, *Podosphaera morus-uvae* in the early 20th century and later two species *E. flexusa* and *E. elevata* which spread from country to country in Europe are serious concerns (Kiss, 2005).

All the historical evidence indicates that plant pathogen invasions have a devastating effect. Appearance of new diseases, resurgence and spread of indigenous pathogens due to increased susceptibility of the exotic

materials, introduction of new pathotypes and minor pathogens becoming severe with specific pathotype strain selection and the consequences there after on the agro-ecology and its management, all add to cost of plant introduction. Chestnut blight, caused by *Endothia parasitica* was introduced on nursery stocks into USA in 1906 and in 25 years exterminated forest chestnuts causing 1000 million dollar loss. Eradication of citrus canker in Florida has costed more than 200 million dollars to date. Annihilation of grape wine industry in France by powdery mildew and downy mildew, coffee plantation in Sri Lanka by *Hemelia vastatrix* are some of the landmark examples of how the pathogens can assume devastating proportions.

In India, considering the vastness of the ecological niches, keeping pace with the dynamics of the international farm trade policy will be a tedious challenge. The free seed trade of the exotic introductions in the domestic market and indiscriminate retailing and their movement into unscheduled regions will be major biotic drivers for the environmentally diverse countries like India, causing an aggravated risk. From 1991 to 1999, four introductions are recorded for India viz., direct introduction of sunflower hybrids, resulted in the introduction of downy mildew, caused by *Plasmopara halstedii*, which became severe. The other recent introductions in India included American serpentine leaf minor, *Liriomyza trifoli*, in 1991, spiralling white fly, *Aleurodicus disperses* in 1993 and white fly biotype B, *Bemisia tabaci* in 1999 (Khetarpal, 2004). The situation is not much different in other countries where many virus and nematode diseases are being reported and detected from new ecological zones throughout the world.

Hence in future, the various aspects of bio-security will be driving a lot of plant protection agenda in most of the countries, since we are not only dealing with agriculture but food, ecosystem and economic security are also implied. Since the farm trade and barriers will have an increasing role and decisive effect in the international politics, the situation will inherently require

coordination between quarantine regulations for imports and effectiveness of the domestic controls. The plant quarantine must be activated at the international and domestic levels simultaneously so that we do not end up in a post mortem approach for the management of inadvertently introduced or aggravated pests and pathogens, as is being done for pomegranate in Maharashtra, where in 2006 bacterial blight had damaged pomegranate cultivation over more than 30,000 ha, causing a loss of Rs. 1,000 crore by affecting 20,000 farmers.

Similarly a delayed domestic quarantine against flag smut of wheat had cost USA to loose wheat trade with China from early nineteenth century till 1950s.

The role of the agro-ecological regions in sustaining the basic food security in countries like India must have a fresh look on the "implementation aspect of the domestic quarantine legislations". Freedom to push seeds of new varieties of exotic or indigenous origin to unscheduled areas needs to be strictly dealt with. Regulated seed and other vegetative planting materials within the country is of paramount importance for progressive agriculture to sustain the benefits of plant introduction. Preparedness with respect to pest risks involved and pathway appraisals should complement these efforts so that inadvertent introductions can be traced.

The domestic quarantine measures should thus assume equal significance like the international quarantine. In the past 40 years indiscriminate seed movement within the country has created more problems than ever and contributed in increasing the cost of crop production. Therefore, alongwith implementation of quarantine on import, even when disease free material is introduced for cultivation, there is a need for data base and capacity building as indicated below:

- a) Preparedness for pest risk and management protocols, taking into account the probabilities and economic impact of pest and pathogens with respect to threatening (likely to enter the region), new (previously unrecognised). Emerging (initially minor), re-emerging diseases (which become low due to management practices) and possibilities of genetic changes (introductions of new mating types or mutations) in the pest populations in new or indigenous environment.
- b) Drafting of emergency action plans, providing legislative support and revoking domestic quarantine

to check the indiscriminate sale and spread of the unscheduled seed and other planting materials in the domestic market to arrest spread of the introduced pathogens and also expanding domains of the endemic pathogen.

- c) In case of germplasm exchange for breeding purposes, the various nurseries must be tested against major diseases as well as screening efforts should be made to test the new materials against minor pathogens, considering the extent of economic damage as Karnal bunt caused to the surplus wheat from north western plain zone of India.

Since increased movement of agricultural produce in future may entail increased spread of pathogens, therefore "preventive"- international and domestic measures are equally important to reduce the cost of plant introduction and contain ever expanding horizons of plant pathogens. A more vigilant and effective implementation of the stipulated quarantine measures at post-entry stage can prevent recurring cost to sustainability as this risk would aggravate with global trade in agricultural commodities.

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