Control of seed-borne pathogens/diseases

Introduction

Seeds are the most critical input in crop production system, and 90% of all the worlds' food crops are raised from seeds. Furthermore, seeds are distributed at large scale in market and are now responsible more than ever for the dissemination of plant pathogens across vast distances. Seed-borne pathogens are continuously imposing a serious threat to crop production and are responsible for the reemergence of various diseases through the introduction of particular diseases into new areas. Seed-borne pathogens are of particular importance because strategies used for their management are insufficient, especially with the availability of limited and outdated chemicals. In the current crop production system, two methods are now being applied for increasing crop productivity, i.e., introduction of high-yielding varieties and avoidance of crop disease incidence. However, seed-borne diseases are responsible for about 10% losses in major crops in India, thereby minimizing the benefits of using high-yielding variety. Planting an infected seed may lead to a widespread distribution of disease within healthy crop and increased number of primary infection sites from where the diseases can disseminate.

Seed Inoculants for Control of Seed-Borne Diseases

Despite the aims for which beneficial microorganisms are applied to the crops, they must be applied in a way that optimize their efficacy in the field environment. Beneficial microorganisms have been delivered by many techniques as liquids and dry formulations. Seed treatment with beneficial microorganisms is a very old practice. Legume seed inoculation with nitrogen-fixing bacteria has a long history and enhances the legume production worldwide. Seed treatment with broad

spectrum fungicides is often essential to escape seedling establishment failure caused by various seed or soil-borne phytopathogens. Application of beneficial microbial antagonists to seed for managing seed and soil-borne pathogens is a model delivery system as it brings in the microbial inoculum to the rhizosphere. Wide range of both fungal and bacterial antagonists have been commercially exploited for this purpose, but their application as seed treatment is very limited.

Various beneficial antagonistic microorganisms including both fungi and bacteria are now being employed as seed inoculants for managing seed-borne diseases in wide range of crops. *Trichoderma* spp. have been extensively evaluated as a seed inoculant for managing seed-borne pathogen such *Ustilago segetum* var. *tritici*, *Septoria tritici*, *Pyricularia oryzae*, *Xanthomonas oryzae* pv. *oryzae*, *Botrytis* spp., *Macrophomina phaseolina*, *Rhizoctonia solani*, etc. *Trichoderma* spp. Have also been reported to promote plant growth through various additional mechanisms such as enhancing root proliferation and induction of systemic resistance.

Seed Biopriming: A New Approach for Seed Inoculation with Beneficial Microorganisms

With the advancement of seed priming, intensive researches have been conducted, and it is now being commonly used for seed inoculation for better crop establishment and yield. Seed priming provides model environment to bioagents for colonization of the seed. “Soaking the seeds in solution containing desired microorganism followed by re-drying of the seeds that result into start of germination process except the radicle emergence is seed biopriming”. “Soaking the seeds in the bacterial suspension for precalculated period of time to allow the bacterial imbibition into the seed is known as biopriming.” Seed soaking in bioagent suspension resulted in activation of physiological processes in the seed. But emergence of plumule and

radical is prevented until the seeds are sown. Seed biopriming has been reported to facilitate the survival of bioagents in/on seed surface, thus providing better plant growth and yield.

Plant Endophytes

Endophytes generally live at least part of their life cycle within the host and provide protection from pest and diseases. There is an increasing interest in exploring the role of microbial endophytes in improving crop performance during biotic and abiotic stresses and application as seed inoculants. Various reports have suggested the augmented induction of defense response in crop plants against wide range of phytopathogens. For example, rice yield was significantly increased when the seeds of rice inoculated with endophytic bacterium *Achromobacter xylosoxidans*.

Chemical Management of Seed-Borne Diseases

Many plant pathogens present in soil constantly attack the plants. Three main types of pathogens, viz. bacteria, fungi and viruses, cause various diseases of plants. Fungi comprise the largest group of pathogens, but bacteria and viruses cause a large number of seed-specific diseases. This is due to the fact that bacteria and viruses are more adept at entering and then travelling through the veins of the plant, a phenomenon known as ‘systemic infection’, and from the vascular system may move into the developing embryos of seed. A lot of diseases can be transmitted both by seeds and through soil (Table1).

Seed treatment is therapeutic when it kills bacteria or fungi that infect embryos, cotyledons or endosperms under the seed coat, eradicative when it kills spores of fungi that contaminate seed surfaces and protective when it prevents penetration of pathogenic fungi into seedling stems.

Table 1 List of some important seed-borne diseases and their causal agents

Disease	Causal organism
Karnal bunt of wheat and triticale	*Tilletia indica*
Bunt of paddy	*Neovossia horrida*
Ergot of pearl millet	*Claviceps fusiformis*
Ergot of sorghum	*Sphacelia sorghi*
Ergot of triticale	*Claviceps purpurea*
Loose smut of wheat	*Ustilago tritici*
I.ate blight of potato	*Phytophthora infestans*
Dry rot of potato	*Fusarium caeruleum*
Charcoal rot of potato	*Macrophomina phaseolina*
Wet rot of potato	*Sclerotium rolfsii*
Common scab of potato	*Streptomyces scabies*
Black scurf of potato	*Rhizoctonia solani*
Basal rot of onion	*Fusarium oxysporum* f. sp. *cepae*
Soft rot of onion	*Erwinia carotovora*
Black rot of sweet potato	*Ceratostomella fimbriata*
Scurf of sweet potato	*Monilochaetes infuscans*
Wilt of sweet potato	*Fusarium oxysporum* f. sp. *batatas*
Bacterial blight in chickpea	*Xanthomonas campestris* pv. *cassie*
Anthracnose of lentil	*Colletotrichum truncatum*
Alternaria blight of chickpea	*Alternaria alternata*
Grey mould (*Botrytis*) of lentil	*Botrytis cinerea*
White mould	*Sclerotinia sclerotiorum*
Stemphylium blight (chickpea- lentil)	*Stemphylium botryosum*
Bright yellow mottle of chickpea	*Alfalfa mosaic virus* (AMV)
Bright mosaic of field pea	*Bean yellow mosaic virus* (BYMV)

Pathogens present in, on and around planted seed are killed by chemical treatments. Certified seed is usually given treatment necessary for the control of certain diseases. Seed treatment can be either physical or chemical. Physical treatments include hot-water treatment, solar-heat treatment (loose smut of wheat) and the like. Chemical treatments consist of use of fungicides and bactericides. Fungicides such as oxathins (carboxin, DMOC) are used to kill embryo infecting smuts of cereal grain. Most eradicative and protective chemicals have a wide range of fungicidal activity. Organic compounds now widely used as protective and eradicative seed treatments include thiram, chloraneb, dichlone, dexon and captan.

The International Seed Testing Association (ISTA) has established seed testing procedures. ISTA came into being in 1924, with the plan of developing and publishing standard procedures in the field of seed testing, and has laboratories in over 70 countries. ISTA has internationally agreed rules for seed sampling and

testing, accrediting laboratories, promoting research and providing international seed analysis certificates and training and dissemination of seed science knowledge and technology to facilitate seed trading nationally and internationally. The regulation of seed-borne diseases must, thus, be based on a systematic preventive approach in the production of seeds combined with monitoring of the occurrence of diseases.

Types of Seed-Borne Pathogens

There are mainly three types of pathogens, infecting seed of different crops. These are as follows.

1. **Internally Seed-Borne Pathogens**

Pathogens establish relationship within the seed and inoculums present within the seed tissues that infect the seeds internally and destroy the endosperm and the embryo and affect seedling germination and development as in the case of loose smut of wheat and barley.

2. **Externally Seed-Borne Pathogens**

These pathogens are present on the seed surface superficially usually as spores, oospores, sclerotia, pieces of mycelium and chlamydospores as in the case of Karnal bunt of wheat, covered smut of barley, downy mildew of pearl millet, etc.

3. **Admixture**

Pathogens are independent of seeds but accompany them as concomitant contamination in the form of sclerotia, infected plant debris, nematode cysts,

infected soil particles, etc., mixed with the seed. Ergot sclerotia get mixed with healthy seeds during threshing.

Chemical Seed Treatments

Management strategies for the control of various seed-borne diseases are mainly based on chemical seed treatment. Chemical seed treatments can be used to achieve a variety of benefits, including: improved emergence, through protection from seedborne pathogens and soilborne pathogens; prevention of seed transmission of seedborne pathogens; protection of above-ground plant parts from infection by airborne pathogens and disease vectors; improved vigor and uniformity of crop growth; prevention of deterioration; fulfillment of phytosanitary requirements and prevention of pathogen spread. Seed treatments are commercially available with contact, locally systemic, or fully systemic activity. Common active ingredients can be used for protection against Oomycetes, fungi, and nematodes.

History of Chemical Seed Treatment

Seed treatment went through a long history in which several substances and chemicals have been tried. The following is a brief description of this history:

1- Brine solution was used as a seed treatment for the control of stinking smut in the seventeenth and eighteenth centuries.
2- Arsenic-based chemicals were used for seed treatment in 1740.
3- Copper compounds were used for the management of stinking smut in 1755 and 1807.
4- Arsenic compounds were banned for seed treatment in 1808.
5- copper sulphate was first time used for the management of grain smut of sorghum in 1885 in India.

6- Organo-mercurial fungicides were used for the management of stinking smut in 1913.
7- Organo-mercurials were introduced for the chemical treatment of vegetable and small grain seeds in 1915.
8- organo-mercurials were used as a seed treatment for the management of sorghum smut in 1925.
9- chloranil and dichlone, two quinone compounds, were introduced as a seed protectant in 1940 and 1943, respectively.
10- Thiram was introduced as a seed protectant in 1941.
11- Captan as a heterocyclic nitrogenous compound was introduced as a seed protectant in 1952.
12- fungicides like oxathin were introduced in 1960.
13- carboxin was introduced for the management of loose smut of wheat in 1966.
14- organo-mercurials were banned for seed treatment in 1982.
15- modern fungicides were introduced for seed treatment in 1990.

Types of chemical Seed Treatment

A. Pre sowing seed treatments

   It is the treatments given to the seeds before sowing to improve the germination and vigour potential and as well as to maintain the health of the seed.

B. Pre storage treatments

   Prestorage treatments of harvest-fresh seed are primarily aimed towards protection against deteriorate senescence during storage. Seed storage which is again threatened by insect and pathogen attack, can also be taken care of by prescribed prestorage seed treatments.

C. Mid storage treatments

Seeds in storage accumulate damage to cell membranes during senescence. Mid storage seed treatments are capable of reducing the age induced damages and restoring the seed vigour to a certain extent besides, the seed viability and productivity of stored seeds are also improved.

Seed Treatment Fungicides

Fungicides are applied to seed prior to planting to provide effective protection against many seed and soil-borne plant pathogens. Chemical (fungicide) treatment guards against the various seed rots and seedling blights that occur during storage or after planting. It is not usually a "cure-all" and will not provide disease protection throughout the growing season after the plants become self-sufficient. (An exception to this would be the control of loose smut by seed disinfection).

Fungicidal seed treatment may be divided into three categories, depending on the nature and purpose of the treatment. These categories are:

A. **Seed disinfection** - Disinfection is the elimination of a pathogen which has penetrated into living cells of the seed, infected it and become established-for example, loose smut of barley and wheat.
B. **Seed disinfestations** - Disinfestation is the control of spores and other forms of pathogenic organisms found on the surface of the seed.
C. **Seed protection** - Seed protection is chemical treatment to protect the seed and young seedling from pathogenic organisms in the soil.

Forms of seed treatment materials

Seed treatment materials are usually applied to seed in one of four forms:

1. **Dust**: It is usually applied 200-250 g / 100kg of seed. Main dis-advantage is dusty condition will prevail during the seed treatment and after handling.
2. **Slurry** (a mixture of wettable powder in water): This type of fungicide is applied to the seed along with soap like water suspension which can be mixed with seed by using special slurry treater.
3. **Liquids**: The use of liquid solution is known as the "quick wet ' method. Here a volatile fungicide is applied to the seed and it throughly mixed with them.
4. **Planter-box** formulations:

Based on composition, seed treatment fungicides may be organic or inorganic, metallic or non-metallic, and, until recently, mercurial or non-mercurial. Before the cancellation of the 'volatile mercurials, fungicides for treating seed were generally classified as volatile and non-volatile. With the elimination of the volatile mercurials, most fungicides now approved for use on seed are classified as non-volatile. When using this type material, complete coverage of the seed is necessary to obtain effective control.

Some of the systemics, a fairly new class of pesticides, may now be used as seed treatment materials. The desirability of having materials that would move inside the seed or plant and control the pest has long been recognized. Such materials are called "systemic." When used according to the manufacturer's recommendation (see label), a systemic moves through the host plant and controls or retards the growth of certain fungi and insects without affecting the host's metabolic system.

Safety

The following safety precautions must be taken:

1. Treated seed must be clearly labelled and under no circumstances be used for feed or food.

2. Seed treatment should be carried out in a well-aerated area. Contact with chemicals through breathing of dusts and skin contact must be avoided. Protective clothing should be worn.
3. As with all pesticides, empty containers should be properly disposed of and never reused in a household or on the farm.