Seed Treatment for Plant Disease Management

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Abstract

Growing through seed is a common practice in many crops around the world. Seed is considered as a vital input in agriculture. Seed health determines the quality and quantity of agricultural products. Several most dangerous diseases originate from soil and seeds (Smut of cereals, Ergot, *Aspergillus* spp. *Fusarium* spp. *Pythium* spp…). Seed carries pathogens in three ways, internally, externally and mixed with seeds. Treatment of seeds with physical agents, synthetic pesticides, biochemical, biological control agents and others in pre-sowing stage is an economic, efficient and easy way for the control of seed borne and soil borne diseases. Seed treatment means the application of fungicides, insecticides, biopesticides agents or any other non – chemical approach in order to disinfect seeds or growing propagules from seed or soil borne pathogens.

Keywords: Seed treatment, Treating agents, Treatment techniques and Plant disease management.

Introduction

The increasing population and consequent demand for food provokes scientists to search more sufficient methods for high plant production. The success of modern agriculture is dependent on a dynamic seed industry that are able to produce on time, capable of producing high quality, free of pathogen and highly yielding cultivar adapted to specific geographic regions and methods of production (du Toit, 2004). Field crops are repeatedly infected by plant pathogens, especially seed borne and soil borne fungi, which causes different types of diseases such as damping off, wilt, smut, seed and root rot and many more (Agrios et al., 2005). These pathogens can reduce of the seed harvested, and in addition they can be preserved in seed lots in the case of seed borne pathogens. Seed treatment with a proper formulation affects the initial development of plants which, in turn, will influence later stages of growth and development and, finally, yield levels (Dawson & Bateman 2000). Seed protection means the application of a treatment to protect the seed from seed borne and soil borne disease causing organisms. Seed treatment is the important first step in preventing later occurring diseases. Furthermore, seed treatments can be useful in reducing the amounts of inoculum around the seed in the soil and also pesticides required to manage a disease, because effective seed treatments can eliminate the need for foliar application of pesticides later in the season (Mancini et al., 2013). Even though the seed treatment cannot replace a healthy seed however it can be an effective way to increase seedling emergence for the low vigor and damaged seeds. Different methods of seed treatment are available which can be applied alone or in combination. They are widely used owing to their broad spectrum in terms of disease control and production yield. In this review, the effectiveness of different seed treatments against the main seed borne pathogens of some important crops is critically discussed.

The main objectives of seed treatment

The main objectives of seed treatment are to disinfect, disinfest or protect seeds from pathogens living on or in the seed. It also helps the crop yield losing, reduce inoculum density, enhance seed vigor, break seed dormancy and supply nutrients to the soil (Bennett et al., 1991).

Seed disinfection: Disinfection refers to the process of elimination a pathogen which has already penetrated and established into living cells of the seed, infected, for example, loose smut of barley and wheat which is colonized in the embryo of the seed. During fungicidal treatment, care should be taken to penetrate fungicides into the seeds and kill the pathogen.

Seed disinfestation: It is the destruction of pathogens that are located on the surface of the seed, and the pathogen only contaminated the surface area of the seed and has not penetrated into the inner part. For example, Bunt smut of wheat and barley.

Seed protection: - In seed treatment, seed protection is chemical treatment to protect the seed and young seedling from pathogenic organisms in the soil in pre – emergence stage.

Techniques and stages of seed treatment

Various techniques are used for the treatment of seeds such as, Physical treatment, Chemical treatment and Biological seed treatment. The process of seed treatment can be applied in pre - sowing seed treatment take place before sowing in order to improve the germination and vigor potential and as well as to maintain the health of the seed from seed borne and soil borne pathogens. Substances used in this method can be fungicides, insecticides and or biopesticides derived from plant and microbes and in Pre - storage stages in which 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.

A. Physical seed treatment: It is considered as safe alternative for the synthetic pesticides. In comparison to the chemical pesticides, it is friendly for ecosystem and living organisms. In the case of agrochemicals, they are less suitable to be used as it degrades land, pollute environment, and therefore the excessive use of synthetic fungicides may induce resistance or reduce the susceptibility of the pathogenic fungus (Yang et al., 2019; Vasilevski, 2003). The main physical seed treatment techniques are hot water treatment, hot steam treatment, dry heat treatment and radiation treatment. In case of thermal treatment, there are two steps. The heating step in which seeds are heated for certain period of time that is calculated for a good disinfestation, followed by the cooling step to stop the heating process in order to keep the seeds from injury due to heating (Godefroid et al., 2017).

1. Hot water treatment

Hot water treatment is an old method used for the control of seed borne pathogens. The temperature range is adjusted to be enough to kill or eliminate the pathogen and do not injure seed viability. The process is started by pre – warming of loose seed in 20 - 37 °C warm water for 10 minutes (Toporek et al., 2021), and the rest amount of temperature vary from seed to seed based on their structure, size and type as listed in table (1). Hot water seed treatment had wide site of usage until synthetic chemicals are introduced to the market. There are several reasons that caused declining in the use of hot water treatment such as reduction in germination percentage, often incomplete treatment, labor costing, time consuming and the disability of hot water treated seeds for storage (they must cultivated as soon as they treated), however it still works for small seeds.

Table.1: Hot water treatment for some seed borne pathogens (Flyod, 2005 and Lancaster, 2014).

Crop / Disease	Pathogen / Diseases	Treatment
Eggplant	*Leptosphaeria maculans*	25 min at 50 °C
Onion	*Purple blotch, Basal rot, Botrytis blight, Downy mildew*	20 min at 50 °C
Brassica leaf spot	*Alternaria brassicicola*	18 min at 50 °C
Carrot	*Alternaria leaf blight, Bacterial leaf blight, Cercospora leaf spot*	20 min at50 °C
Cereal loose smut	*Ustilago segatum* var. *tritici*	5 h at 21 °C pre-soak + 1 min at 49 °C + 11 min at 52 °C
Millet downy mildew	*Sclerospora graminicola*	10 min at 55 °C
Rice blast	*Magnaporte grisea*	6-12 h in cool water + 1-2 min at 50 °C
Rice leaf spot	*Helminthosporium oryzae*	7 min at 51 °C
Moong bean black rot	*Xanthomonas campestris* pv. *Phaseoli*	20 min at 52 °C
Tomato canker	*Clavibacter michigansis* ssp. *Michigansis*	60 min at 53 °C
Pea blight	*Pseudomonas syringae* pv *pisi*	15 min at 55- 60 °C

2. Dry heat treatment

Another way of thermal treatment is solarization of seeds where seeds are exposed to sun light (solarization). This method is simple and usually applied in warm regions. It is less common than hot water treatment. Dry heat treatment, which has been developed recently, is considered as a common physical treatment for seeds and has been applied to various crops against pathogens and stock insect pests (Shi et al., 2016).The procedure is easy; seed are spread on polyethylene sheet, bricks and or other substances for certain period of time and then are used for cultivation. This strategy can totally inactivate harmful seed-borne bacterial pathogens such as *Erwinia*, parasitic pathogens such as *Fusarium*, *Alternaria*, and *Cladosporium* (Jung, 2004), as well as the cucumber green mottle mosaic infection (Kim and Lee, 2000). The period of exposing to dry heat is 70 **°C** for 90 minutes for inactivating most diseases in which the percentage of seed treatment may reduce however, seed vigor will not be affected (Meng et al., 2016).

3. Humid heat (steam) treatment

In this method, seeds are treated with steam of boiling water. Seeds are spread on the siew on the top of boiling pot and then water is boiled. The humid heat kills the internally and externally seed borne

pathogen. It is comparatively effective than dry heat and there is lower possibility of seed damage.

4. **Radiation seed treatment:** In this method seeds are exposed to different radioactive irradiations such as X, Gama

and UV rays, which have been reported to be successful in very few cases. Based on the report by (Araujo et al., 200.) Irradiation with microwaves (MWs) or ionizing radiations (IRs) are the most promising pre-sowing seed treatments as Gamma-rays delivered at low dose have showed to enhance germination percentage and seedling establishment, acting as an actual 'priming' treatment. However the method has not widely used because the exposure to radiation sufficient to kill pathogen often kills seed.

B. Chemical seed treatment

Introduction and ban of arsenic (used from 1740 until 1808) is the key milestones in the history of modern seed treatment till then a continuous research and advancement in this technology is going on (Sharma et al., 2015). Physical seed treatment was widely used in 20th centuries until synthetic agrochemicals were introduced to market. Since then, chemical seed treatment is so common. There are many reasons for why chemical seed treatment is widely used, such as the easiness of application, economically cheapness, and more successful compare to physical method. Beside of these advantages it also has some disadvantages, for example, the side effects to ecosystem and its parts, human health, soil structure, development of resistance, and in recent reports indicated that chemicals used for the seed treatment eliminate pathogens also affect the growth of endophytes (Ayesha et al., 2021). Seeds after chemically treatment must be colored in order to prevent the mistaken use for food. Chemicals used for this purpose can be systemic, organic and or inorganic.

Table.2: The common chemicals used for seed treatment (Jayaraman et al., 2018)

Captan	Broad-spectrum, non-systemic fungicide against various seed decay and damping-off fungi, such as Aspergillus, Fusarium, Penicillium, and Rhizoctonia. Also used as spray for pre-harvest fungal disease control.
Organo mercurial	Broad-spectrum, non-systemic and fungicide against various fungi and bacteria. Never be used for spray or soil application.
Thiram	Broad-spectrum, non-systemic fungicide labeled for a wide range of field crops and vegetable crops to control seed and soil-borne fungal pathogens.

Zineb	Broad-spectrum, non-systemic fungicide against various seed decay and damping-off fungi. Also used as spray for control of foliar and pre-harvest fungal pathogen
Maneb	-do-
Chloroneb	Broad-spectrum, non-systemic fungicide against various fungal pathogens.
Copper oxychloride	Non-systemic seed disinfectant against fungi and bacteria.
Copper hydroxide	-do-
PNCB (pentachloronitrobenzene)	Non-systemic fungicide. It is especially useful against seedling fungi, such as Rhizoctonia and Fusarium.
Fludioxonil	Broad-spectrum, non-systemic fungicide effective against various seed decay and damping-off fungi, such as Aspergillus, Fusarium, Penicillium, and Rhizoctonia.
Carboxin	Systemic fungicide with good activity against smuts and fair activity against other fungal pathogens. Carboxin is commonly formulated with other fungicides or insecticides to increase the pest control spectrum
Carbendazim	Broad spectrum, systemic fungicide that controls seed-borne and soil-borne fungi. Not effective against Pythiaceous fungi. Can be used as foliar spray for pre-harvest disease control
Benomyl	Broad spectrum, systemic fungicide that controls seed-borne and soil-borne fungi. Not effective against Pythiaceous fungi. Not widely used due to resistance development in pathogens.
Difenconazole	Broad spectrum, systemic fungicide that controls common bunt and loose smut. Can be used as foliar spray for pre-harvest disease control

Imazalil	Broad spectrum, systemic fungicide that controls common bunt and loose smut. Can be used as foliar spray for pre-harvest disease control.
Metalaxyl	Narrow-spectrum, systemic fungicides. They are effective only against Pythium, Phytophthora, and downy mildews. Often used in conjunction with a broad-spectrum fungicide, such as Captan or Fludioxonil. Should not be used for spray as alone. Several new mixed formulations available as below.
Fludioxonil + Metalaxyl	Broad spectrum systemic fungicide for seed- and soil-borne diseases caused by Fusarium, Pythium and Rhizoctonia, along with suppression of Aphanomyces root rots and root rot caused by Phytophthora.
Tebuconazole + Metalaxyl	Multiple mode of action fungicide used for the control of seed-, seedling and soil borne diseases.
Tebuconazole + Metalaxyl + Pyraclostrobin	For multiple mode of action, broad spectrum control of key seed- and soil borne diseases.
Ipconazole and Metalaxyl	Seed treatment fungicide that combines two different modes of action for contact and systemic activity for broad spectrum disease control for both seed and soil borne diseases.
Tebuconazole (TBZ)	Broad-spectrum, systemic fungicide useful against common bunt and various seed decay and damping-off fungi, such as Fusarium and Rhizoctonia is commonly formulated with other fungicides to increase the disease control spectrum
Triadimenol	Broad-spectrum, systemic fungicide that controls bunt and smut and other fungal diseases.
Streptomycin	Broad spectrum antibiotic that kills a several bacteria. It can be used to control seed-borne populations bacterial pathogens. Not recommended for spray.

C. Biological seed treatment

Seed treatment with beneficial organisms such as bacteria, fungi and their extracts stimulate seed germination, plant growth and protect seeds from a wide range of biotic and abiotic stresses (Metwally et al., 2022; Rocha et al., 2019). Bacteria, especially (*Bacillus thuringinisis* spp.) are inoculated to the seeds prior the sowing so

that they enhance seed germination, plant growth and later protection of seedlings from pests and diseases. Seed are treated with preidentified beneficial bioagents to protect the seed and supplement the nutrients. Use of bioagents for seed treatment is ecologically sound and biologically sustainable and considered as an essential component of organic farming. Based on the report by the Seed Treatment and Environment Committee (FIC) of the International Seed Trade Federation (2009), of the biological agents' bacteria counted about 84% where fungi were 16%. The bacteria included *Streptomyces*, *Bacillus*, *Pseudomonas* and *Enterobacter*. Fungi products consisted of various species of *Phomopsis*, *Ectomycorrhizae*, *Trichoderma Cladosporium* and *Gliocladium*.

Table. 3: The most common bio agents used for seed treatment (Callan et al., 1997; Kumari et al., 2018).

Bacteria	Pseudomonas, Bacillus, Clavibacter, Enterobacter
Fungi	Trichoderma spp., Aspergillus flavus., Curvularia pallecens and Chaetomium indicum
Botanicals	Leaf powder of azadirachta indica, Vitex negundo, Prosopis, Acacia, Pungam, etc.
Nutrient supplementations	Rhizobium, Azospirillum

The success of biological agents mostly depends on the potential of biological agent, the quantity of agents applied to the seeds, soil types and the inhibition from other microbes (Waller, 1998). The use of natural compounds, which could be of organic or inorganic in nature, is another useful tool. As organic compounds comprise plant extracts, essential oils, as well as purified microorganism compounds (Spadaro et al., 2017). Most of the studies about seed disinfection with natural compounds have focused on cereal seed borne pathogens.

Methods of seed treatment

Seed treatment by emersion techniques: Seed emersion methods are those where seeds are steeped for varying periods of time in aqueous or solvent based liquids at ambient or raised temperatures with or without the addition of chemicals to eradicate

seed borne organism (Black and Bewley, 2000).

Seed dressing: Typically the foremost common strategy of seed treatment is seed dressing.in dressing; seeds are dressed with specific pesticides which may be as dry powder or in the form of slurry (Ehsanfar and Modarres, 2005). It can be operated from very basic level to a very modern level and at farm and industry. Low cost earthen pots can be used for mixing pesticides with seed or seed can be spread on a polythene sheet and required quantity of chemical can be sprinkled or spread on seed lot and mixed mechanically by the farmers. An exact amount of chemicals materials must be prepared and weighed before mixing in order to achieve the appropriate efficacy of seed treatment.

Seed coating/Pelleting: It is the process of coating seed with enough seed ingredients to make the seeds larger, heavier, and consistent in size for sowing using seed drills. Pesticide pelleting is used to protect soil organisms and pests, as well as to repel birds, ants, and rodents. Seed coating require a special binder is used with a formulation to enhance adherence to the seed. This technique usually used in industrial purpose and requires advanced treatment technology (Arias-Rivas, 1994) The earliest methods of treating seed with fungicides were relatively simple. The first method used involved piling the seed to be treated on a solid surface and then dusting the top of the pile with the fungicide (Nault et al., 2006).

Fig.1

Fig. 2

The simple technique for hot water seed treatment fig1, Seed treated with chemicals fig2 (Kanter, 200.0)

Conclusion

Seed treatment is the first step in controlling plant diseases. It is very important for the eliminating injurious organisms and protection of seeds and seedling from plant pathogens during germination and even after emergence. Seed treatments promote seedling establishment and help reduce yield and quality losses due to many pathogens and insects. The ability of seed treatments to control fungal diseases has made them a great success story of disease prevention. Physical seed treatment has very long history due to its beneficial activity in controlling many devastating diseases especially smut of cereals. Physical seed treatment such as hot

water treatment is applicable for almost every type of seed for internally and externally seed borne diseases. The germination percentage of physically treated seeds may reduce during the process, so that it is necessary to increase the amount of seeds for sowing. Chemical seed treatment is cheaper, easier and most effective way. It not only eliminates seed borne and soil borne pathogens, but also reduces the amount of applying pesticides in later stage so that lower the exposure of grower to agrochemicals. Meanwhile lessens their impact on environment. Moreover, it is also reported that seed treatment enhance the percentage of germination compare to untreated seeds. Chemicals used for seed treatment can be a good source of trace elements. Seed treatment with biological agents not only eliminate seed pathogens but also have plant growth promoting activity that stimulate the growth of seedling, roots, tolerance against abiotic stresses and its consequent yields . Additionally, biological seed treatment agents have increasing interests in organic method of production. Seed treatment is a common procedure in developed countries in form and in industrial level. Unfortunately, this step of plant diseases control is left behind in Afghanistan, as it is followed in very low percentages their fore the need for post emergence chemical application is higher than other countries.

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لنډيز

د تخم پوسيله کرنه د نړۍ په سطحه د کرلو يوه عامه طريقه ده. تخم د کرهنې حياتي او لمړنی واحد بلل کيږي. دتخمونو پاکوالی او له ناروغيو څخه خلاصوالی د کرهنيزو محصولاتو د کميت او کيفيت اندازه ټاکي . يو زيات شمېر نباتي ناروغۍ (لکه د غلو تورکي، د سبزيجاتو د چپه کيدو ، فوزاريمي مړاوي کيدو او داسي نورې..) له خاورې او تخم څخه منشا اخلي چې ډيرې خطرناکه او د نه کنترول په صورت کښې د محصولاتو د ستر زيان سبب کيږي. تخم په درې لارو نباتي پتوجنونه له ځان سره خپروي، يوشمېر نباتي پتوجنونه د تخم په جنين کښې قرار لري لکه د غنمو د لوخ تورکي عامل (*Ustilago tritici*) چې دې ډول خپرېدو ته (Internally seed borne) وايي. ځيني پتوجنونه د تخم په باندنۍ سطحي پورې نښتي وي لکه د غنمو پټ تورکي عامل (*Tilletia tritici)* چې دې ډول خپرېدو ته (Externally seed borne) وايي او يو شمېر پتوجنونه لکه د غنمو د ناخنک ناروغۍ عامل (*Claviceps purpurea*) بيا د تخمونو سره په ګډ ډول خپرېږي چې دې ډول خپرېدو ته (Mixed with seed) وايي. له کرلو مخکې د تخم تداوي د فزيکي عواملو ، کيمياوي درملو او بيولوژيکي موادو پوسيله د نباتي ناروغيو د عاملينو او په خاص ډول هغوی چې له خاورې او تخم څخه زېږي د تخمونو د پاکوالي او روغ ساتلو اقتصادي ، اسانه او ګټوره لار ده. له کرلو مخکې په کيمياوي درملو د تخمونو تداوي د ناروغۍ د مخنيوي تر څنګ د نبات د پاره د ضروري عناصرو په پوره کيدو کښې هم مرسته کوي. د بيولوژيکي عواملو پوسيله د تخمونو تداوي د تخمونو په روغ ساتلو، ښه ټوکيدنې، ښه ودې او بلاخره د حاصلاتو په زياتوالي کښې مهم رول لوبوي.

کليدي ټکي: د تخمونو تداوي، د تخمونو د تداوۍ مواد، د تدواوۍ تخنيکونه او د نباتي ناروغۍ کنترول.