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Review Article

Seed Coating with Fungicides and Various Treatments for Protection of Crops: A Review

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A B S T R A C T

Application of chemical products, biological products or physical treatment over to the seeds before sowing so to suppress, control or keep away pathogens, insects and other pests that ruin the healthy seeds, seedlings, or plants. Seed treatment is a revolutionary technology for crop protection and management that grants many advantages to cultivators and represents one of the most efficient instruments in precision farming.

Keywords: Seed Treatment, Fungicides, Pathogens, Seed Germination

Introduction

Every day farmers face an array of demands and challenges, among all the main concerns is to grow their crops disease-free, bother to mitigate the damage of plants, and most important is to protect the environment along with providing food for communities across the globe. Though the above problems have been fixed up to some extent with time by the help of modern technologies in the market and the responsible use of chemical products such as insecticides, herbicides and fungicides application to the soil, seeds or on growing crops.

Seed treatments have facilitated to improve the yields of many diverse types of crops by providing the insurance of a consistent stand across a wide variety of soil profiles, cultural practices, and environmental conditions (Lorenz et al., 2009). The techniques permit broad-spectrum seed treatment crop management products to protect seeds from pre- and post-growing pests and diseases. Seed treatments offer an inexpensive crop input that is applied straightly on the seed using highly successful technology.

Procedure and Process

Chemical Process

Dry Powder treatment is the oldest method of seed coating but later different formulation came in the market to protect the users from the hazard of toxic dust. Selection of formulation for seed treatment is mainly decided by the viability of formulation type, suitability of lively ingredients, application machinery, available storage stability, preservation on seed distribution on seed, clean-up of equipment, compatibility with other products, product and worker safety aspects, commercial necessities, market traditions for seed treatments, competitive products.

Dry Powder Seed Treatments (DS)

This is the oldest formulation type of treatment. They are alike wettable powders the difference is only that they enclose stickers such as mineral oil or dodecylbenzene in place of wetting and dispersing mediators (Microft et al., 2008). They are red to show safety markers for the dressed seeds. Powdery nature of the product makes users apply with simple apparatus, mostly concrete mixers or drums.

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This has made them so valuable and cheap in developing nations where more sophisticated equipment is much costly or not obtainable. This formulations store in good health and cause very low germination difficulty to the seeds. Seeds and stickers may require to be mixed to progress seed retention. The seed treatment process is always very dusty and untidy, which direct to poor plant hygiene and user safety problems. Seed treatment areas and equipment are not easier to clean because the dry powdery compounds do not wash water (Alan, 2005). That's why dry powder seed treatments are not often used in the well-developed state but developing counties use them in a large range.

Examples: Carbendazim-25%DS, Tebuconazole-2.5%DS, Carbosulfan-25%DS, Carboxin-37.5 + Thiram-37.5% DS

Water Slurriable Powders (Ws)

It is similar to wettable powder formulations in that it is to make it easy slurry into water some kind of wetting and dispersing agents are used with the powder for application to the seed. The surfactants used are lignosulphonates and aliphatic alcohol ethoxylates. However, polyphosphate acts as a flocculating agent used in the formulation to prevent the slurry of fungicide particles from settling too rapidly during the seed treatment process. They also contain a red pigment as a safety marker for the dressed seed. These formulations are well admired in Europe, particularly in France for fungicide management. The advantage of Water Slurry formulations is easy to manufacture, better storage constancy, water dilatability makes it easy for plant cleaning (Knowles, 1998). The main drawback of WS formulations is it makes formulation area untidy and messy because it requires constant stirring during making up the slurry during application to the seed.

Examples: Difenconazole-3%WS, Imidacloprid-70%WS, Thiram-75%WS, Carbendazim-25% + Mancozeb-50% WS

Flow Able Seed Treatments (FS)

Flow able seed treatment concentrates ready for Application (RFA) products, which are mainly applied by pumping the fluid suspension product directly onto the seed. Formulations are much alike to Suspension Concentrates (SC) and very regular contain identical agents. The red pigment indicates as a safety marker on prepared dressed seed (Castro et al., 1998) Flowable concentrates necessitate careful choice of gelling and thickening agents to organize viscosity to avoid separation of particles, whilst at the same instance having to low enough viscosity to easily pumpable straightly onto the seed, even at low temperatures. The main benefits user can have with flowable seed treatments are water-based and water dilatable, low possible for germination problems, better retention on seed, no powder dusting issues, comfortable to clean up seed treatment equipment. The main shortcoming of flowable seed treatments are needs lengthy formulation process, storage constancy may be influenced by temperature extreme, and high loadings may cause glueyness and deprived flow properties of seed (Alan, 2005). Now the formulation has become the most popular in Europe since they are concentrated formulations and too safe to use because they are water-soluble.

Examples: Imidacloprid-48%FS, Thiomethoxam-30%FS, Thiram-40%FS, Thiophanate methyl + Pyroclostribin 50%FS

Emulsion Seed Treatments (ES)

The emulsion seed treatment process is based on Oil-in-water emulsion formulations. Similar to EW formulations for seed treatment/ dressing. A steady mixture or emulsion for application to the seed applying either in direct mode after diluting the products. In Present FS (flowables for seed treatment) are accessible. They are suspensions of solids. Particle size reduces the Surface area for solids. For fluid, surface area/coverage will be greater.

Example: Metalaxyl-M-31.8%E.

Microcapsule Seed Treatments (CF)

CF is a modification of flowable emulsion seed treatment formulations. The main function of CF is to change the emulsion droplets into capsules by microencapsulation methods. To reduce the operator handling exposure these systems are adopted. Its active components having potential skin irritancy issues. Force ST Syngenta has successfully produced this type of product known as Evict, containing a capsule suspension of tefluthrin. The same product is also manufactured by Bayer Crop Science.

Water Dispersible Granule Seed Treatments (WG)

To beat the problems of dirtiness and sedimentation with water slurriable powder products (WS), a small number of powders have been transformed into water-dispersible granules (WG).

Examples: Carbendazim-16.7%WG, Cymoxanil-6.7%WG, Oxadixyl-16.7%, Thiram-33.4%WG

Film Coating and Pelleting of Seeds

The main problem with pesticide formulations is that after treatment is that major part of the pesticide falls off the surface of the seed. This problem can be short out by coating or pelleting the outer surface of the seed. This process guarantees that almost all of the pesticide is preserved by the seed until it is prepared for planting (Reddy et al., 1999).

Seeds treated in this method are also effortless to handle in the seed drills because the seeds flowing rate of seed is best at this method and not influenced by a buildup of dust and powders. The major drawback of seed coating and pelleting is the price. Since techniques are not economic for high productivity, low-cost seeds such as cereals, but

generally used for elevated value crops such as sugar beet, vegetables including horticultural seeds.

Seed Pelleting

Seed planting is a unique process, which uses a thick layer of inert substance to the seed and alters its shape and volume. The inert materials are generally clay or limestone dust, and markers such as gelatin, cellulose polymers, or polyoxyethylene glycol-based waxes are mixed as binders. Sugar beet and vegetables are generally pelleted at a high level in Europe. The seeds are rotated in rotating mills or drums and at the same time, water and powdered coating materials are mixed properly (Hoeptting et al., 2012). The combination of materials is selected to adhere to the seed, mold around the seed properly, sufficient power to endure transport and drilling, make easy for seed germination, chemical compatibility with the fungicide/pesticide. The main aim of pelleting is to get better seed handling and drilling. This is attained by escalating the size of small seeds and by altering the shape of embarrassedly-formed seeds to a more spherical shape. The extent of the pellet coating means that pesticides can be segregated at different layers of the coating. Seed pelleting is a costly form of seed management and is only of use in a restricted number of crops.

Micro Emulsion Gel Technologies

During seed dressing for improved adherence on the surface of seeds, gel structure pickups the features of the stickiness of active components, for control of seed-borne infectivity, Very fine coating along with more preservation time.

Controlled Release of Seed Coating Formulation Technology

Releasing the active components in controlled fashion provides the delivery of agrochemicals when required; there is no contradiction with the controlled release of agrochemicals and seed germination. For the protection of transplanted crops sustained delivery of active compounds, extended delivery for straightly seeded crops, extended protection time to compare the needs of the growing plant and lower any phytotoxicity of seed treatments on germination.

ZW Seed Coating Formulation Technology

A combined manufactured of Capsulated Suspension (CS) and concentrated mixture (EW) is a fixed suspension of microcapsules of the active constituents and tiny droplets of active ingredient(s) in the liquid, generally intend to dilute with water before use. In the microcapsules, the active component is present into separate, inert, polymeric microcapsules. Blends of the active ingredient in encapsulated are given to present to provide a broader spectrum of pest management, ZW formulations are so easy to use and measure, dust-free, non-combustible and provide better solubility with water.

Examples: Lambda Cyhalothrin-25.0 CS + Chloropyriphos-10.0 EW

Nano Gel Based Seed Coating Formulation Technology

It is Nano-sized hydrogel methods and highly cross-linked systems in nature connecting polymer systems, which are either co-polymerized or non-numeric. Rapid occurrence in the field of nanotechnology has initiated the need for developing Nano gel systems which proven their capacity to deliver active components is restricted, sustained, and targetable manner. A wide range of polymer systems and the easy changeable of their physicochemical characteristics have given benefits for the multipurpose form of Nano gel products. Such types of Nano gel formulation could have a better future in seed dressing/coating since its lower particle size, large surface area, and greater adhesive properties.

Physical Treatment

Hot Water Treatment

Hot water treatment is a traditional method to manage various seed-borne diseases by applying temperatures hot enough to destroy the pathogens but not many hosts are enough to kill the seed. This technique of treating seed prolong to be a standard process of pathogen removal which is more eco-friendly and effectual in comparison to chemical treatments, however, they may weaken the seed viability. A classic example of hot water treatment is for the fungal disease blackleg and the bacterial disease black rot of crucifers. Before practicing the hot water treatment pre-warm free seed in a porous cloth bag, such as cheesecloth for 10 minutes at 20^0C water. After this step, dip the bags in cold water to discontinue heating action. Once seeds have cooled, spread them thinly on a paper towel to allow drying. The quantity of seed should be just lettuce, celery, cabbage, radish, turnip, and other crucifers. Hot water treatment may damage or not practicable for seeds of peas, beans, cucumbers, beets, sweet corn, and some other crops. Old seed may be severely injured by this technique.

Dry Heat Treatment

Thermal seed treatment has been applied practically in various ways. The basic method of thermal treatment is solarization, here the seeds are warmed by irradiation from the sun mostly applied in warm countries, but is of little attention is given in industrial agriculture due to low accuracy and complexity with the large-scale application. Dry hot air is being used against pests in grain stores and is practiced in Australia at capacities up to 150 tons/hour, but it has been said that it performs poorly against fungal infections in seeds. Dry enough to allow thorough and

instant wetting. Place the pre-heated seed in a water bath that will hold the recommended temperature. The extent of treatment must be 'exact'. It must be carefully and correctly done. Fluctuation in temperature used may not control the disease or may destroy the seed.

Magnetic Treatment

The advantageous results of pre-sowing magnetic treatments for improving germination factors and biomass buildup have been described for a wide variety of plants and lately reviewed by Teixeira da Silva and Dobránszki (2015). In these studies, various MF (Magnetic Frequency) strengths have been experimented ranging from 0 to 300 mT. Magneto-primed seeds result in improved seedling rates, vigor, and sprouting biomass or root growth. Another exciting characteristic of MFs-treatments showed that they emerged to enhance tolerance to biotic or abiotic stresses (Javed et al., 2011) as a consequence of the antioxidant response activation. Amplified antioxidant enzyme actions of Superoxide Dismutase (SOD), Catalase (CAT), and Glutathione Reductase (GR) were described in magneto-primed cucumber seeds. In concurrence with these findings, highlighted a decreased proliferation of superoxide radicals (O^{2-}) in magneto-primed soybean seeds. As a result, MFs-treatments have the extra potentiality to be used to minimize the drought- or disease-stimulated adverse effects on crop farming.

Ionizing Radiation Treatments

Gamma Irradiation

Among the diverse radiobiology features, the classification of the γ-rays impacts on seeds is a subject that is recently receiving clear attention. Experiments carried out have been principally focused on yield and seedling performance of seeds by applying low dose rate and/or low total dose γ- irradiation. Gamma-rays straightly interact with the cell constituents at multiple stages, acting with membranes, proteins, and nucleic acids (Kovács and Keresztes, 2002). However, an indirect action is also reported during the genesis of Reactive Oxygen Species (ROS) from water radiolysis ROS spread and break down organelles and cellular macromolecules. Nonetheless, the biological causes γ-rays have been confirmed to be firmly dependent on the intensity, dose-rate, and exposure time. Relating to seed treatments, γ-rays exposed at low dose boost up germination percentage and seedling establishment, performing like a real 'priming' treatment.

X-Ray irradiation

The results of X-rays on seeds are still not completely understood. However, some authors observed a stimulatory effect on leaf growth when seeds were irradiated with a 0.65 Gy dose. Some study results showed that seedling and growth of functional leaves were not significantly hindered by rising irradiation dose, which suggested some resistance is working on the way to irradiation. Later, the radio-resistance of the Microtome cultivar was supported by the minor structural perturbations detected in leaves with slight impairment of the photosynthetic efficiency, when seeds were exposed with high doses of X-rays. The recognition of radio-resistant species or seed lots can be a major success for the design of space-oriented agriculture (Arena et al., 2014).

Ultraviolet Irradiation

Treatments of seeds with low doses of UV-C (3.6 kJ m-2) were used in cabbage to extract out black rot. This UV-C seed treatment also improves the quality and growth response of cabbages under the greenhouse environment. UV-C- treated lettuce seeds (exposure to 0.82 and 3.42 kJ m^{-2}) seedlings are challenged with salt stress probably as a result of the improved free radical scavenging action detected in the leaf tissues (Ouhibi et al., 2014).

Microwave Irradiation

Microwaves comprise radiation its rising evidence shows that MWs cause diverse biological effects resultant of field strength, waveforms, frequencies, modulation and duration of exposures (Vian et al., 2006). While the impacts of microwaves on animals and humans were extensively examined minutely. From a seed technology perspective, non-lethal MWs treatments have been widely used for seed health before storing or sowing (Reddy et al., 1995). Surprisingly, harmful MWs exposure is being used for hindering seedling of weed seeds buried in the field. MWs process applied results soil heating up to 80°C and weed growth was completely restricted. As a result, microwaves acts as a suitable non-chemical substitute for weed management in greenhouses from ornamental plant nurseries.

Advantages of Seed Treatment

Grower Benefits

It is proved by its quick acceptance; seed treatment provides considerable advantages for farmers and permits them to grow high-quality crops. Seed treatments contribute to earlier and speedy planting, higher plant populations, and higher crop yields (Crop Life Foundation, 2005). Following planting, seed treatments offer effectual control against the early season, below-ground and above-ground insects and diseases, and decrease the necessities for extra rescue treatments or replanting. Seed treatment protects the seed itself. Which has high intrinsic value, and raise the value of the yield crop through improved yield and considerably higher product prices since 2005?

Healthier Crops

Seed treatment provides a useful technique of protecting

the seed from pathogens and other pests, which contributes to best-quality crop production. Broad-spectrum crop protection products are being used to treat seed management pre- and post-emergence pests and diseases. Pesticides are used as seed treatments offer a healthy, stable crop by controlling pests.

Positive Environmental Impacts

Seed treatment exactly places the crop protection product on the exterior of a tiny seed, successfully reducing the need to use formulations over entire fields. This reduces power off-target coverage to crop protection products for both animals and humans. Modern seed coating supply goods can benefit high levels of efficiency for the organize early-season pests or diseases at a much-lowered practice rate compared to many foliar or soil applied substitutes (Hutmacher, 2005). Seed treatment usage with today's products lowered the land surface contact to the active constituents .just imagine the comparison of 1 hectare of land with soil used application of active ingredient - result in 10,000 m^2 of land in exposure with the active components. If the products were used in-groove, then the contact land surface could be decreased to 500 m^2. But, applying seed treatment would leave only 50 m^2 of surface contact to the active ingredient, minimizing environmental impact.

Precision Application

On applying seed treatment crop protection goods enhance accuracy and effectiveness by decreasing the applications of insecticides applied to the land surface. The fixed use of a crop protection product via seed treatment lowers soil surface coverage by up to 90% compared to the product used in-furrow and up to 99% compared to a surface application. Seed treatment is a suitable relevance method in which the crop protection formulation is applied straight to the mark (Kubik, 2010).

Uniform Loading

Seed treatment is the foremost technology in exactitude agriculture. It's not only about seed treatment primarily used in a closed system; their loading rate per acre is very less compared to all other kinds of applications. Besides the advent of Genetically Modified seeds, the plant has focused research on optimizing the seeding rate needed to optimize production.

Integrated Pest Management

FAO International Code of Conduct on the Distribution and Use of Pesticides (Revised version) adopted in 2002 defines Integrated Pest Management (IPM) as meaning "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment (Chandler, 2008). IPM highlights the enlargement of a healthy production with the least possible disorder to agro-ecosystems and supports natural pest control systems". Seed treatments can be applied as a principal method in a successful Integrated Pest Management Program for sustainable agriculture since they target the insects and diseases with lesser amounts of active constituents per hectare and are not established into the atmosphere. In many cases, without the use of seed treatment, growers would have great difficulty in controlling different seed-borne and early season seedling pests and diseases and would have to choose to have more pricey and less environment-friendly techniques.

Improvements to Seed Treatment Equipment

Application technology for seed treatment has advanced from a sickening application of ounces per hundred weights of seed (cwt) to a precise application of milligrams per individual seed. There have been significant advancements in an application using an apparatus designed to use loading rates of milligrams. Computerized systems evaluate the total product application rate for each lot of seed, regulate the seed and product run, and make corrections as needed for each new lot.

Economic Impacts

Also, to provide very much effective protection against pests and infection, seed treatments have a noteworthy economic effect on sales and marketing, mainly in the U.S. and Europe. In 2011 the international seed treatment market was valued at $2.43 billion. Insecticides accounted for 52% of the entire market revenue, alone by fungicides accounted for 35% of revenue. The international fungicide treated seed market is growing at a compound yearly growth rate of 9.2% and is expected to attain $1.8 billion by 2020.

Uniqueness of Innovative Seed Coating Formulations

Seed are living organisms so there is no tolerance for a delivery system that negatively affects the health and/or contributes to untimely death of seeds and/or seedlings. Treated seeds must be robust enough to withstand handling multiple times after treatment from the time the application is made, to packaging g in bags and/or bins and finally in transport to the final destination to the grower. Since seeds are a 3-dimensional substrate, they must be treated uniformly so that the active ingredients are evenly distributed to provide optimum protection in a harsh growing environment. Seed treatment products can be quite sophisticated in that they may be formulated with one or more fungicides in combination with one or more insecticides, i.e., they can be multi-functional products delivered in a single container. Because seed is sold as a commodity, certain varieties or genetic traits are often

distinguished in the marketplace by the addition of a unique color and/or cosmetic enhancement. Because seed is the target, the impact on the environment is minimal (treatment on the seed, seed in the ground). The danger of excess runoff does not exist (Wiltrich et al., 2004). Considering the adverse effects of chemicals on ecology and living being, some alternative techniques were developed and are now a day's being applied for treating seeds in the case of chemical used in agriculture, they are less appropriate to be utilized as it degrades soil, environment, and therefore the human and animal food (Chapman and Harris, 1981; Vasilevski, 2003). Thus, it is significant to examine the use of a sustainable process, such as physical methods in this century. New technologies to imply must be economically viable.

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